FINAL INTERIM REPORT
OF EXISTING INFORMATION

U.S. RADIUM CORPORTION SITE
ORANGE, NEW JERSEY

October 10, 1986

DOCUMENT CONTROL NO. 295-WP1-DJ2F-1

R E M II

PERFORMANCE OF REMEDIAL RESPONSE ACTIVITIES AT UNCONTROLLED HAZARDOUS WASTE SITES

U.S. EPA CONTRACT NO. 68-01-6939

CAMP DRESSER & McKEE INC.
ROY F. WESTON, INC.
WOODWARD-CLYDE CONSULTANTS
CLEMENT ASSOCIATES, INC.
ICF INCORPORATED
C. C. JOHNSON & ASSOCIATES, INC.

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1.0 INTRODUCTION

This Interim Report summarizes the information resulting from previous investigations at the U.S. Radium Corporation site and identifies areas where additional data will be required to prepare a Feasibility Study (FS) for remediation of the site. Investigations required to produce these data will be conducted during the Remedial Investigation (RI) of the site and will be detailed in the Work Plan. The work for this site has been authorized under Work Assignment Number 177-2L67.0.

The U.S. Radium Corporation site consists of the High and Alden Streets site, which is the location of the former U.S. Radium processing facility; the adjacent vicinity properties; and a number of satellite properties where associated radium extraction, production, application, and distribution may have taken place. Figure 1-1 shows the location of the High and Alden Streets site, the vicinity properties, and the potential satellite properties.

Previous investigations at the High and Alden Streets site have identified elevated radiation exposures both within the buildings and on the grounds. Elevated concentrations of radium-226, thorium-230, uranium-234, and uranium-238 have been found in samples of soil and concrete taken both outdoors and inside buildings on the site. These contaminants have resulted in elevated gamma radiation levels and indoor radon and radon daughter concentrations that exceed relevant public health standards. At several locations on the processing site, long-lived surface alpha contamination has been found that exceeds generally accepted criteria. Several buildings on the site have not yet been investigated.

Gamma radiation surveys of 31 properties in the immediate vicinity of the High and Alden Streets site revealed elevated gamma radiation exposure rates at some properties.

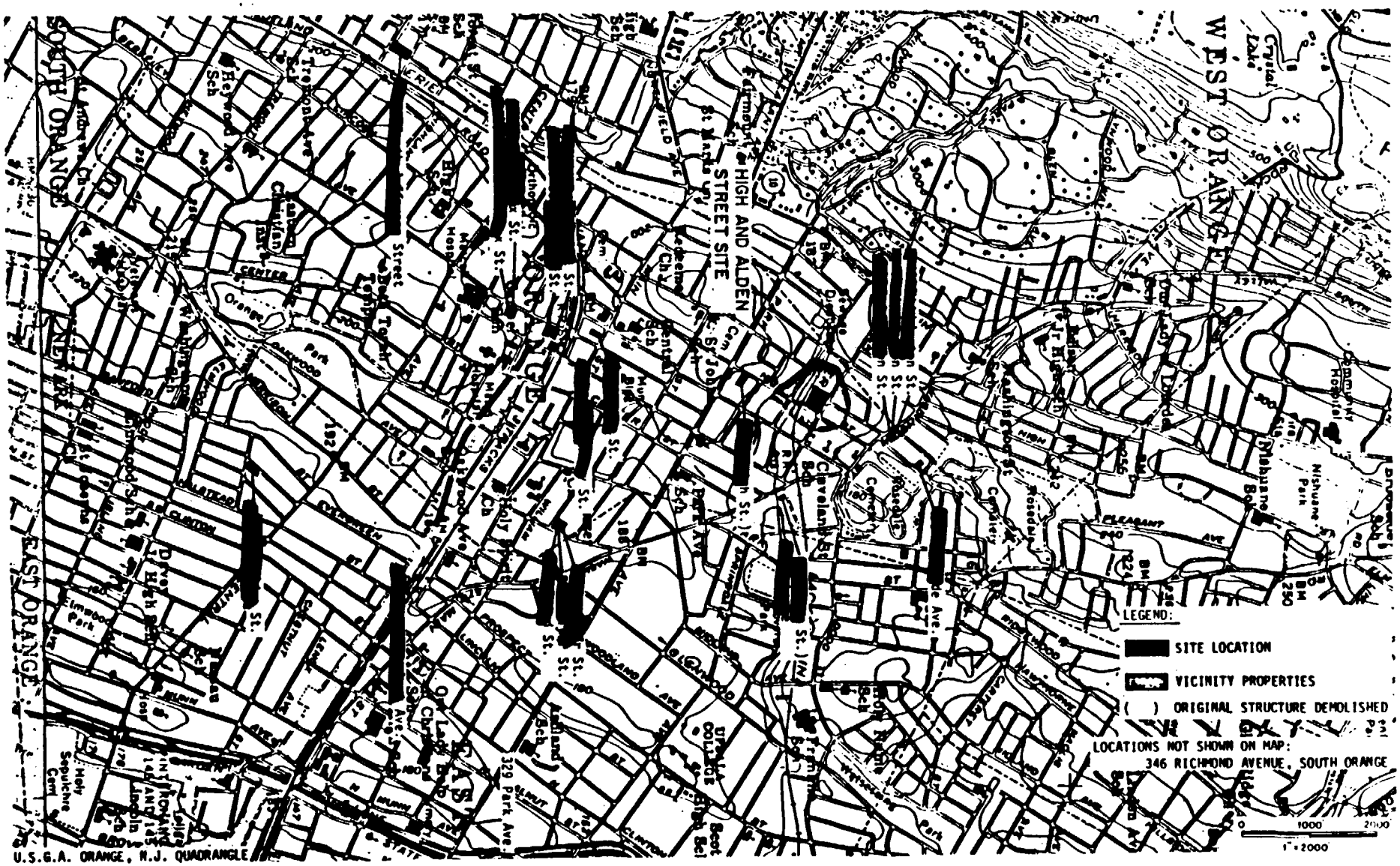

FIGURE 1-1

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U.S. RADIUM CORPORATION SITE
LOCATION OF U.S. RADIUM CORPORATION SITE
INCLUDING POTENTIAL SATELLITE PROPERTIES

Potential satellite properties have been identified by searches of U.S. Radium Corporation records and by gamma scans of neighborhoods identified in a 1981 gamma survey overflight of the area surrounding the High and Alden Streets site. Elevated levels of gamma radiation have been found at most of the potential satellite properties investigated to date. Radon concentrations inside the buildings at these properties have been determined so far to be within normal ambient levels. Surface alpha activities are generally within normal background range. Seven satellite properties have not yet been screened for radioactive contamination. Other potential satellite properties may be identified during the course of the Remedial Investigation.

In the fall of 1982, the U.S. Radium Corporation site, including satellite properties associated with the manufacture and handling of radium-based products, was placed on the federal Superfund National Priority List.

The overall objectives of the Remedial Investigation are to characterize the extent of contamination at the High and Alden Streets site and its vicinity properties, identify the satellite properties associated with U.S. Radium Corporation activities, and characterize the nature and extent of contamination at those locations.

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2.0 SITE DESCRIPTION

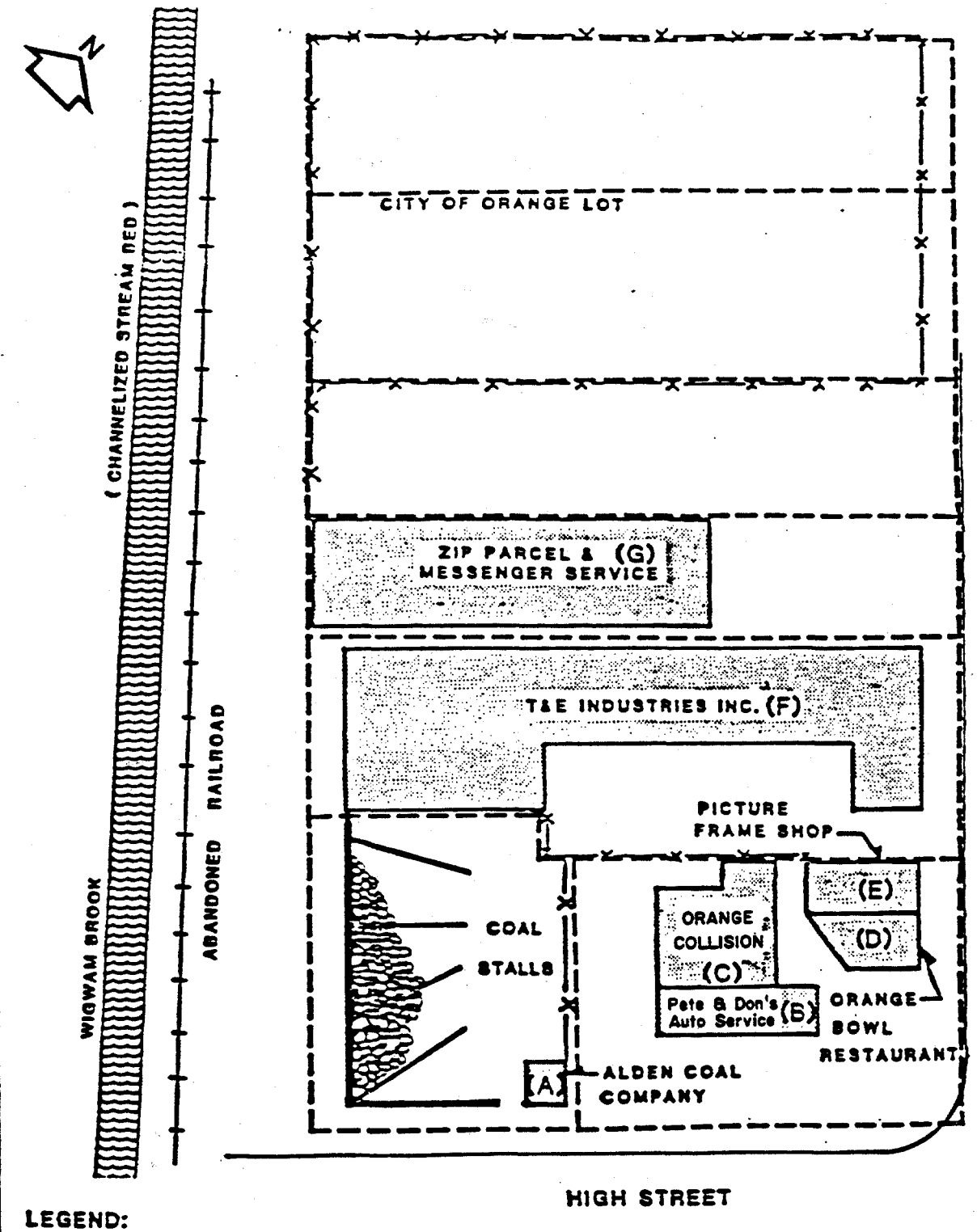
The U.S. Radium Corporation site consists of the High and Alden Streets site, which is the location of the former U.S. Radium Corporation processing facility; the adjacent vicinity properties; and a number of properties where activities associated with radium extraction, production, application, or distribution may have taken place.

Information included in this report was extracted from U.S. Environmental Protection Agency (EPA) files and a number of other sources listed at the end of this report. Additional data were gathered in discussions with officials of the Cities of Orange and East Orange and examination of their records, discussions with property owners, and visits to the site.

2.1 SITE LAYOUT

The location of the former U.S. Radium Corporation processing plant is in Orange, New Jersey. The former properties occupy approximately two acres on the southwest corner of the intersection of High and Alden Streets. It has been reported that during the period of the facility's operation in the 1920s, nine buildings were located there (Eng, 1980). Since then, some structures have been removed or incorporated into the seven existing buildings that now house small businesses. Figure 2-1 is a map of the buildings on site today. Figure 2-2 is a map of the property showing the former and existing buildings.

Discovery of the elevated levels of contamination at the High and Alden Streets location prompted EPA to conduct an aerial gamma radiation survey over an area of approximately 12 square miles, centered on this site, in May 1981. The results of this survey were mapped and the identified anomalies were screened at ground level by the New Jersey Bureau of Radiation Protection (BRP) for elevated radioactivity. In 1985, the data from the survey were reprocessed and remapped. This resulted in significant changes in the location and size of several anomalies.



LEGEND:

— — PROPERTY LINES

NOT TO SCALE

REF: NUS, 1984

Figure 2-1

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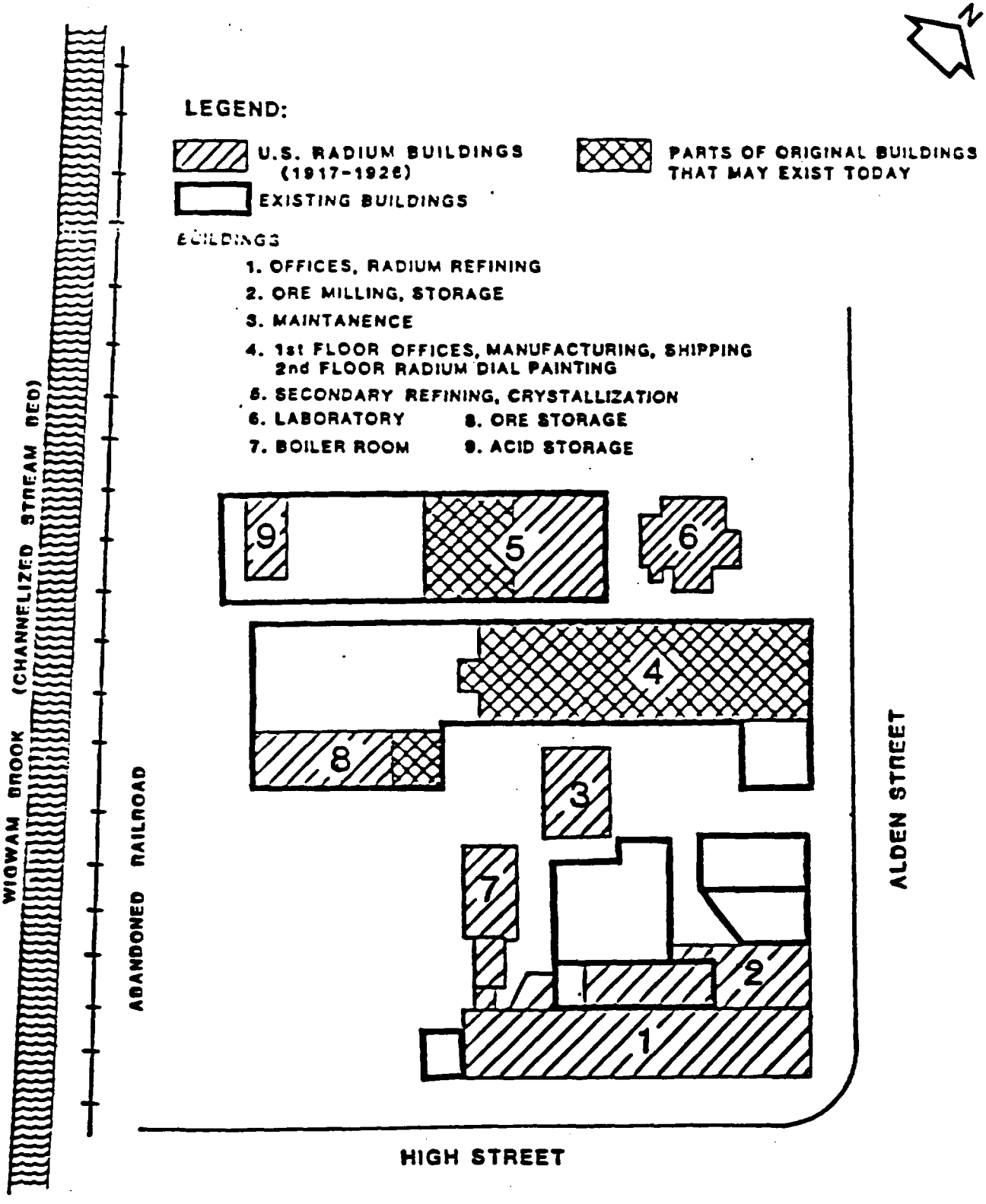
Site Map
High and Alden Street Site
U.S. Radium Site, Orange, New Jersey



REF: NUS, 1984

NOT TO SCALE

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FIGURE 2-2
U.S. Radium Corporation Site
FORMER AND EXISTING BUILDINGS
HIGH AND ALDEN STREET SITE

Approximately 140 vicinity properties have been identified to date, occupying approximately 21 acres immediately surrounding the High and Alden Streets site as shown in Figure 1-1. The buildings in the area are mostly single and multifamily homes, situated on small lots. Many were built before or during the years that radium was processed. Commercial and light industrial properties are also in the area. The vicinity properties are located within the area of elevated radium-related gamma activity identified in the rectified map of the aerial survey results.

Approximately 20 satellite properties are located throughout the Cities of Orange and East Orange, and the Village of South Orange. Some of the properties have been screened for radioactive contamination by BRP (NUS, 1984), some by EPA's REM II contractors, and some still have not been screened. Results of the screening are discussed elsewhere in this report (Sections 3.4.1 and 3.4.2, Appendices A and B).

Street, Orange

The building at this address is a two-story frame structure with an office on the first floor. There is undeveloped property immediately north and west of it. The building is within a large area of elevated gross gamma activity located by the 1981 flyover, in both the 1981 and 1985 maps.

Avenue, Orange

This building is a two-story frame structure. The lower floor is used for light-manufacturing activities and the upper floor is an unoccupied residential apartment. This building is within the same area of elevated gross gamma activity on the 1985 map as [redacted] Street. It is outside the anomaly on the 1981 map, but was investigated because of its known association with U.S. Radium Corporation activities.

Orange

This is a three-story brick building. The first floor houses a rental agency and the second, a dental laboratory. The use of the third floor is not known. This building is outside any area of elevated radioactivity identified by the aerial survey and was identified from U.S. Radium Corporation records.

[redacted] Street, [redacted] Street, [redacted] Street, Orange

These three properties form a contiguous group. All three buildings are two-story frame houses. All three are included in an area of elevated gross gamma activity as shown on the rectified map. They lie immediately south of the anomaly shown on the 1981 map.

[redacted] Street, [redacted] Street, [redacted] Street, Orange

These three properties form a contiguous group. All three buildings are two-story frame houses. All three are outside the area of elevated gross gamma activity identified from the aerial survey in the 1981 map, but are included in the relocated anomaly on the 1985 map.

[redacted] Avenue, South Orange

This is a two-story frame house built in 1920. It is outside the area of the aerial survey, but was identified as a residence of a U.S. Radium Corporation officer, who was known to have handled and marketed radium sources.

[redacted] Avenue, Orange

This is a two-story frame house located in the same area of elevated gross gamma radioactivity as the houses on [redacted] Street. It is also identified in court transcripts as a location where dials were painted.

[redacted], East Orange

This is a three-story duplex apartment building built about 80 years ago. It is outside any area of elevated gross gamma activity identified from the aerial survey, but was identified as a residence of a U.S. Radium Corporation officer.

[redacted] Street, Orange

This is a large multi-story brick building used as an office, warehouse, and light-manufacturing space. It is outside any area of elevated gross gamma activity identified from the aerial survey. It was used as a business address of U.S. Radium Corporation in 1934.

[redacted] Avenue, Orange

This is now a parking lot adjacent to [redacted] Street.

[redacted] Avenue, Orange

The building at this address is an older three-story frame house with a small store attached to the front. It is within an area of elevated gross gamma activity, but has also been identified as a location of U.S. Radium Corporation activities.

[redacted] Avenue, Orange

This is a three-story brick building with a grocery on the first floor and apartments on the upper floors. It is next door to another satellite property, [redacted] Avenue.

[redacted], East Orange

This apartment building, built in 1919, appears to be abandoned, although there may still be some occupied apartments. This address has been identified as the residence of an officer of U.S. Radium Corporation.

[redacted] Street, East Orange

This apartment building is still occupied. Its address has been identified as that of the residence of a U.S. Radium Corporation officer. However, the document identifying this address is dated 1922, while the building permit for this structure is dated 1923 (Byrnes, 1986).

[redacted] Street, Orange

[redacted] Street was vacated and demolished in the early or mid-1960s. The southbound extension of [redacted] Boulevard runs approximately along the old right-of-way. This address may have been the location of dial-painting activities.

[redacted] Street, Orange

According to the City of Orange Tax Assessor's Office, there is no property with this address. The block from [redacted] Street [redacted] Street is outside any area of known elevated gamma radiation. The address was identified by EPA as a possible potential location of U.S. Radium Corporation activities.

2.2 ENVIRONMENTAL SETTING

2.2.1 LAND USE

The U.S. Radium Corporation site is located in an older, well-established urban area of Essex County, New Jersey, which includes commercial, light industrial, and residential properties. Most of the local buildings are small, low-rise structures.

2.2.2 CLIMATE AND METEOROLOGY

The U.S. Radium Corporation site is located in north-central New Jersey and is influenced by a moderate climate. Table 2-1 provides the monthly climatological data for temperature, precipitation, wind direction, and wind

TABLE 2-1

CLIMATOLOGIC DATA

New Jersey Weather Service Office
Newark International Airport, Newark, NJ
30 Year Average

Month	Temperature (^{o}F)	Precipitation (in.)	Prevailing Wind Direction	Average Wind Speed (mph)
January	31.4	2.91	NE	11.2
February	32.6	2.95	NW	11.6
March	40.6	3.93	NW	12.1
April	51.7	3.44	WNW	11.4
May	61.9	3.60	SW	10.0
June	71.4	2.99	SW	9.3
July	76.4	4.03	SW	8.8
August	74.6	4.27	SW	8.7
September	67.8	3.44	SW	9.0
October	57.5	2.82	SW	9.3
November	46.2	3.61	SW	10.1
December	34.5	3.46	SW	10.7
Annual	53.9 (Avg)	41.45 (Total)	SW (prevailing)	10.2 (Avg)

(RW17/80)

speed at the Newark, New Jersey, Weather Service Office Airport Meteorological Station, averaged over 30 years. The station, located at Newark International Airport, is about eight miles from the site.

Based on the annual evapotranspiration rate of about 25 inches, net precipitation is about 16.5 inches. Periodically, the area receives heavy periods of precipitation resulting in considerable runoff.

2.2.3 TOPOGRAPHY

The topography of the U.S. Radium Corporation site is governed by the Triassic lowlands of the Piedmont Physiographic Province and the northeast-southwest trending Watchung Mountains, which rise 600 feet above sea level and approximately 200 feet above the Triassic lowlands.

The High and Alden Streets site is located in an urbanized area of Orange, New Jersey, in the eastern foothills of the First Watchung Mountain. The area in the immediate vicinity of the property is generally flat and graded with a gentle slope towards the southeast.

2.2.4 SURFACE WATERS

Wigwam Brook is the only surface water in the vicinity of the High and Alden Streets site. The shallow brook is located along the southwest boundary of the site and flows east into the Second River, which is approximately two miles from the High and Alden Streets site. The brook itself is channelized by concrete conduit over its entire length. Along the High and Alden Streets site, it is an open channel with a concrete bottom and embankments and with portals to allow surface drainage into the brook. Storm water runoff and sanitary wastes from the property are discharged to the municipal sewer system, and some surface drainage from the rear of the site empties into Wigwam Brook. It is not certain whether the sewer systems in the vicinity of the site are combined or separate or where the outfalls are located (Petrocelli, 1985).

2.2.5 GEOLOGY AND SOILS

The underlying bedrock in the area of the U.S. Radium Corporation site is of the Piedmont Plateau of the Newark Group's Brunswick Formation (Figure 2-3). The Brunswick Formation is a nonmarine intermontane basin deposit at least 6,000 feet thick with a general northeast-southwest strike and a 10 degree dip northwestward. It consists predominantly of reddish brown siltstones interbedded with red sandstone. Lower portions of the Brunswick contain isolated deposits of conglomerate. The Brunswick is considered an important source of ground water for the surrounding area.

Extensive field surveys of exposed Brunswick sections during a National Uranium Resource Evaluation (NURE) study revealed no anomalous radioactivity. The study concluded that the Brunswick was a geologically unfavorable uranium host (Bendix, 1982).

Beneath the Brunswick Formation in descending stratigraphic position are the Lockatong and Stockton Formations (Figure 2-4). The formations are at least 1,000 feet thick in the study areas and lie a minimum of 6,000 feet below the surface. Major exposures of these formations outcrop east of Essex County in the New York and New Jersey Palisades and fault blocks in western and central New Jersey. Although these formations are favorable uranium hosts, their distance from the site is sufficient to negate any possible influence on background levels of radioactivity at the site.

The sediment overburden consists primarily of unconsolidated deposits of Pleistocene glaciers and postglacial meltwaters. Figure 2-5 indicates that the site is underlain by stratified drift, deposited by postglacial meltwater streams. These deposits are organized into beds of similar sediment size. This organization occurs during the depositional process as sediment grains fall out of suspension in order of size and density. The "sorted" deposit exhibits greater porosity and permeability as compared to a heterogeneous deposit such as till. Porosity values are independent of sediment size, while permeability decreases with sediment size. Thickness of the unconsolidated sediments is largely controlled by the underlying bedrock

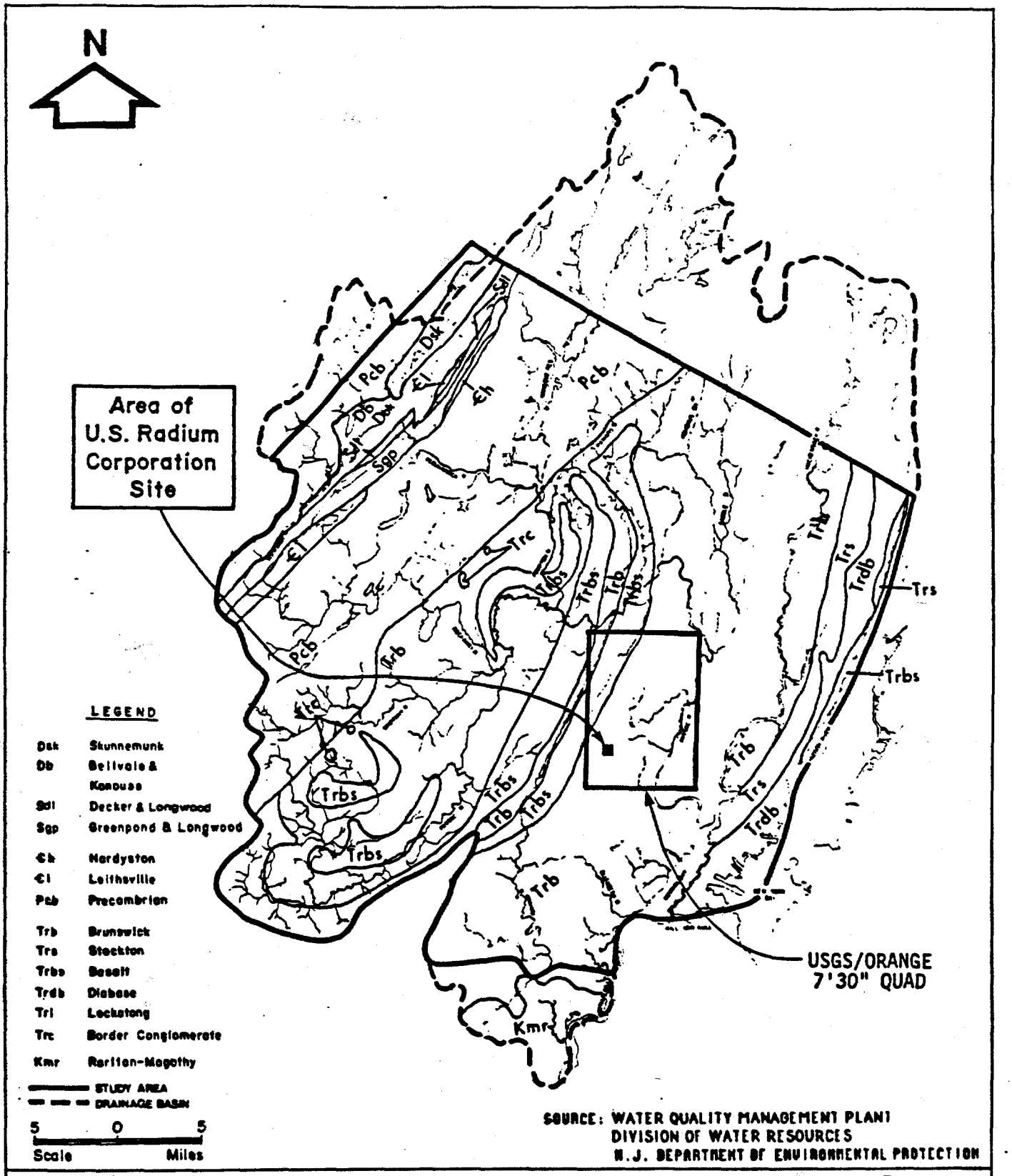

Figure 2-3

Bedrock Geology of the Northeast New Jersey Area

U.S. Radium Site, Orange, New Jersey

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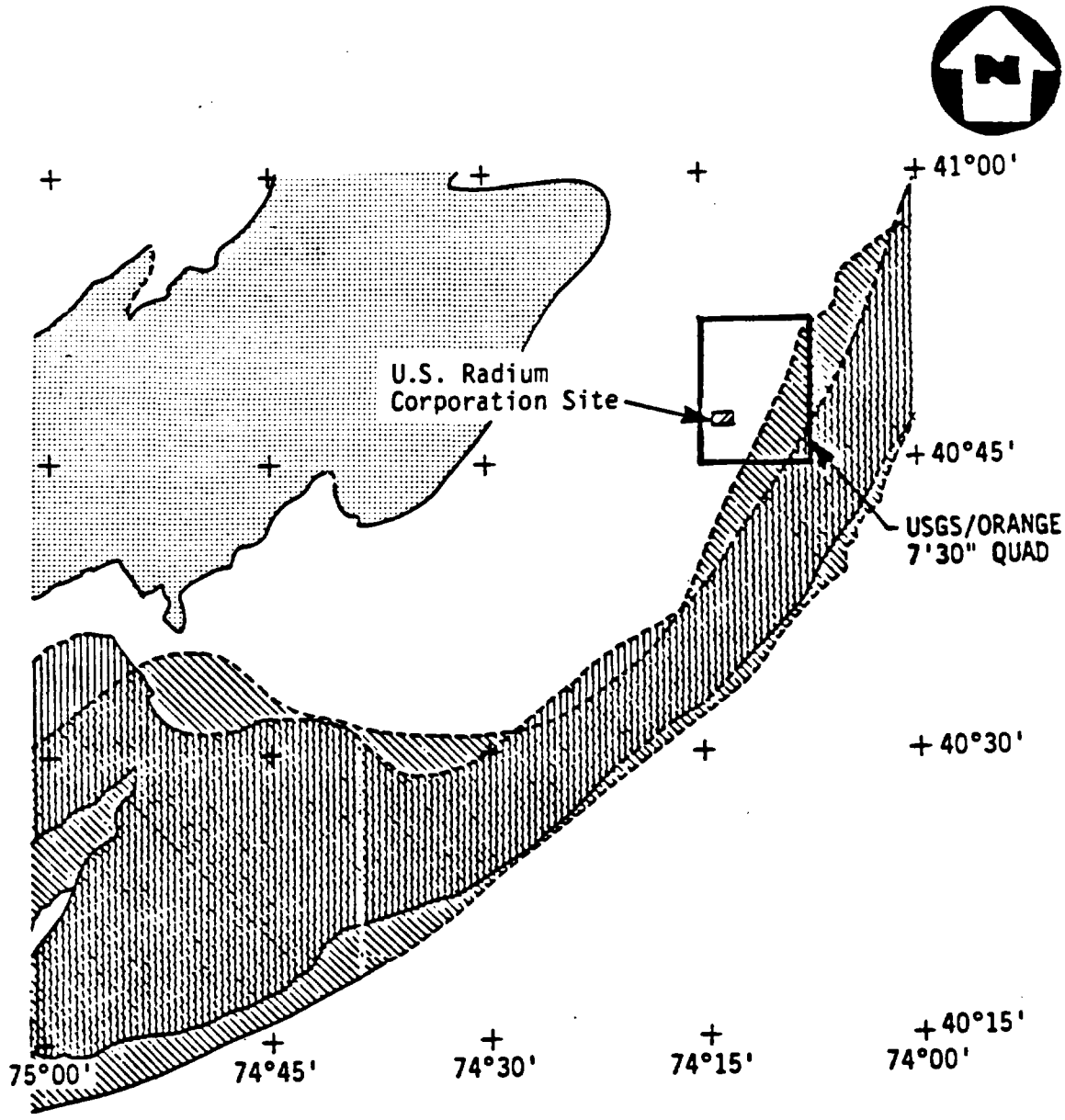

LEGEND:

READING PRONG
FAVORABLE FOR ANATECTIC AND ALLOGANIC URANIUM DEPOSITS

STOCKTON FORMATION
FAVORABLE FOR NON-CHANNEL CONTROLLED, PENECONCORDANI
SANDSTONE URANIUM DEPOSITS

LOCKATONG FORMATION
FAVORABLE FOR ORGANIC-RICH, TERRESTIAL URANIUM DEPOSITS

SCALE 1"=16 miles

SOURCE: BENDIX, 1982

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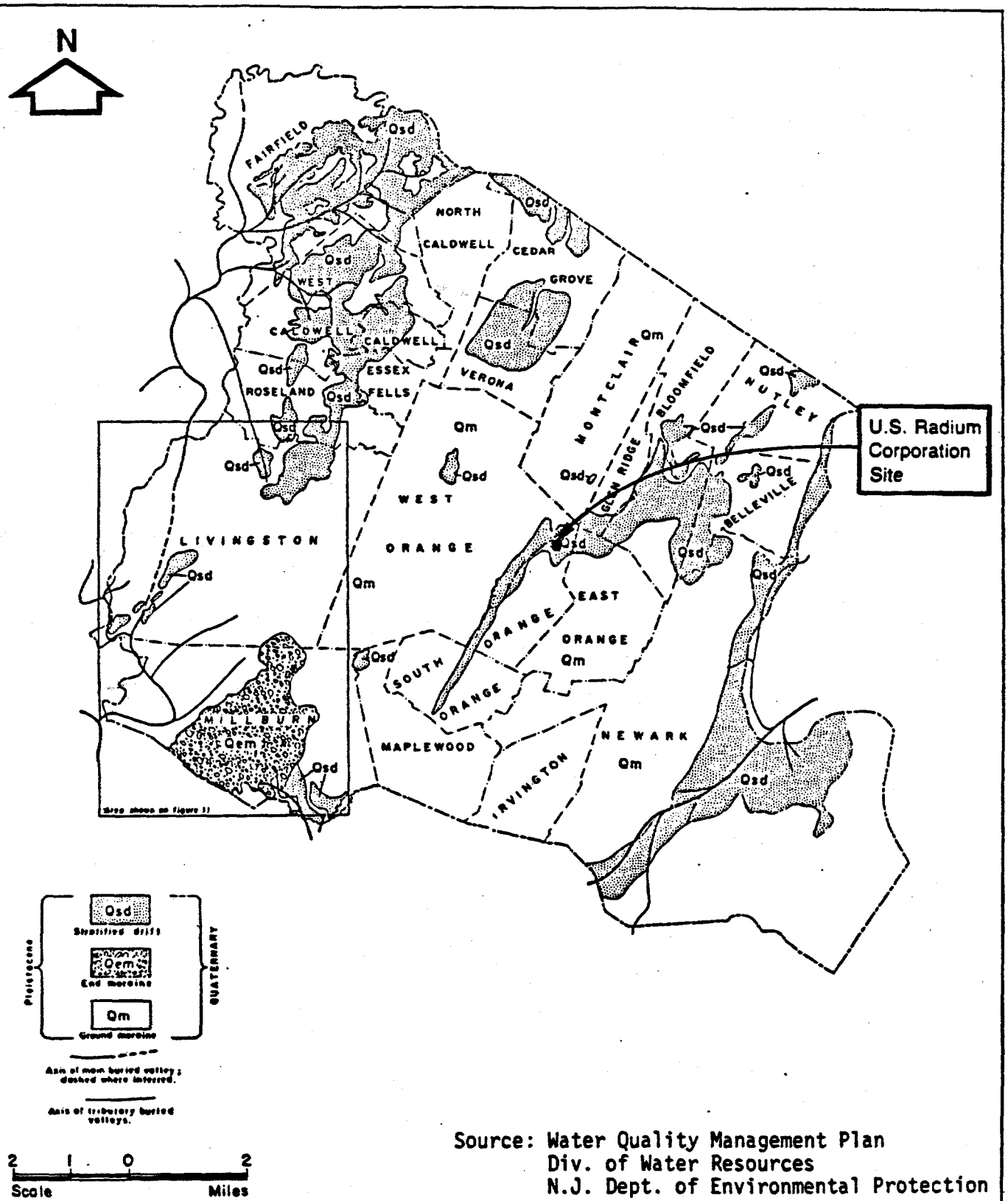
Figure 2-4
U.S. Radium Corporation Site
AREAS FAVORABLE FOR
URANIUM DEPOSITS



Source: Water Quality Management Plan
Div. of Water Resources
N.J. Dept. of Environmental Protection

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Figure 2-5
Surficial Geology of Essex County, New Jersey
U.S. Radium Site, Orange, New Jersey

topography. Local well information indicates a relatively shallow depth of unconsolidated sand and glacial drift generally 20 feet thick, which overlies the red shales of the Brunswick Formation.

2.2.6 GROUND WATER

The uppermost aquifer system in the U.S. Radium Corporation site area exists in the unconsolidated glacial sediments overlying the bedrock. Ground water is also stored and transmitted through the joints and fractures of the Brunswick Formation.

Unconfined ground water occurs in the stratified surficial deposits where the water is free to migrate from the surface through the porous sediments. Horizontal flow of ground water in the area is generally to the southeast. Significant quantities of ground water are not generally yielded by these deposits, and the overburden aquifer is not known to be used for domestic or industrial supplies.

The Brunswick Formation has low primary porosity, and ground water moves along vertical and horizontal fractures under confined or semiconfined conditions. According to pumping tests conducted by the United States Geological Survey, ground water in the formation is generally transmitted in a northeast-southwest direction (NUS, 1984). Due to the limited extent of joints and fractures, it is unlikely that ground water is transported more than two or three miles.

2.2.7 DRINKING WATER

The Orange Municipal Water System serves the entire industrial and residential communities of the City of Orange. Water for the municipal system is supplied by an open reservoir in West Orange Township and seven ground water wells in Essex County including three deep bedrock wells in the City of Orange. The reservoir is more than five miles from the High and Alden Streets site, and the nearest municipal well is located on Gist Place in Orange, less than 1,000 feet southeast of the former U.S. Radium facility. The Brook Alley well is located in a City of Orange municipal parking

lot approximately 3/4 mile south of the High and Alden Streets site, and the Oakwood Avenue well is in Orange Park, less than 1-1/2 miles south of the site. One municipal well is in West Orange Township, more than six miles west of the U.S. Radium property, and the remaining three wells are in Millburn Township, more than seven miles southwest of the site. A 1982 analysis of water from the municipal supply showed a gross alpha activity of 0.17 pCi/l (Marucci, 1985). The National Interim Primary Drinking Water Standards allow activity up to 5 pCi/l before water must be tested for radium. New Jersey Department of Water Resources information indicates that several private wells are in the area (NUS, 1984).

2.3 SITE HISTORY

The High and Alden Streets site in Orange, New Jersey, was the location of the Radium Luminous Materials Corporation's processing plant from 1917 to 1926. The company, which was founded by Dr. Sabin Arnold Von Sochoky and Dr. George S. Willis, refined radium from carnotite ore and manufactured a number of products containing radium, including a zinc-based luminous paint. The company also employed over one hundred workers, mainly women, to paint instruments and watches with this luminous paint. In 1921, Radium Luminous Materials Corporation became the U.S. Radium Corporation.

It has been reported that nine buildings were located on the U.S. Radium Corporation property during the 1920s (Eng, 1980). Since that time, some structures have been removed or incorporated into existing buildings. Figure 2-1 is the site map and Figure 2-2 shows the reported locations of the former buildings on site.

During the plant's operation, carnotite ore containing from 2 to 4 percent uranium oxide was shipped by rail from Paradox Valley, Colorado, to the Orange, New Jersey, facility, and was stored in Building 8. Approximately one-half ton of ore was processed daily at the plant (Eng, 1980). Acid solutions for the radium extraction process were stored in Building 9. In Building 2, the ore was milled and treated with hydrochloric acid to extract uranium, radium, and vanadium. A barium and sulfuric acid solution

was then added to promote precipitation of the metals. The radium-barium sulfate precipitate was sent to Building 1 for further refining, the vanadium compound was shipped to steel companies, and the uranium compound was sold for use as pigment for ceramics or disposed as waste. The radium-barium sulfate was autoclaved with a soda ash solution and the resulting carbonate residue was transferred to Building 5 to be refined into radium bromide salt by fractional crystallization.

Process wastes and tailings were discarded on unused areas of the main facility, usually at the rear of the property near the railroad track. Some of the newer buildings on the site were built directly over the waste material.

Building 6, which is now demolished, was a Victorian house that was used as a laboratory.

The ground floor of Building 4 was used for offices, a shipping area, and a paintbrush-manufacturing area. The second floor was the location of the dial-painting operations. According to U.S. Radium Corporation records and other sources, dial-painting and other radium-handling activities took place at a number of other locations.

During the 1920s, the lot now occupied by the Alden Coal Company (Building A) was not owned by U.S. Radium Corporation, but may have been leased by it to store coal and ore.

U.S. Radium Corporation ceased radium-processing operations at the High and Alden Streets facility in 1926.

In 1943, U.S. Radium Corporation sold the lot that is now occupied by Zip Parcel and Messenger Service (Building G) and the lot occupied by T&E Industries, Inc. (Building F). In 1949, the company sold the corner lot of the original facility, now occupied by Buildings B, C, D, and E.

Two lots adjacent to the western boundary of the processing facility were occupied by private homes until the buildings were dismantled in 1951. The two properties were then used for parking lots until 1978 when they and the lot adjacent to Building G were purchased by the City of Orange.

No subsequent occupants of the High and Alden Streets property are known to have used radium at that location.

2.4 PRIOR INVESTIGATIONS

In 1924, the Health Officer investigated unexplained deaths and illnesses of young women employed at U.S. Radium Corporation's Newark, New Jersey, plant (Eng, 1980). The matter was then referred to the New Jersey Consumer's League and the New Jersey Department of Labor. The investigation determined that the cause of death of the women was anemia and necrosis of the jaw. In addition, the results of an autopsy performed by the Essex County Medical Examiner on Dr. Edwin D. Lehman, the company's chemist, indicated that he had been contaminated with a radioactive substance. Later in 1924, Dr. Cecil K. Drinker of the Harvard School of Public Health was retained to conduct a separate investigation for U.S. Radium Corporation (Eng, 1980).

In 1925, Dr. Hoffman of the Prudential Life Insurance Corporation initiated an investigation of the workers' illnesses for the New Jersey Consumers League. The Harvard Investigation Report, published in August 1925, identified high levels of radiation at the U.S. Radium facility, but could not establish radium poisoning as the cause of the workers' deaths, even though Dr. Drinker found evidence of radium poisoning among the plant workers. However, in October 1925, the Essex County Medical Examiner presented the first proof, based on the autopsy of a U.S. Radium Corporation dial painter, that the cause of death was radium poisoning (Eng, 1980).

In 1926, the U.S. Radium Corporation ceased radium-processing operations at the High and Alden Streets site. By 1932, the American Medical Association had removed radium from its listing of new remedies for internal administration.

In 1957, the Radium Research Project was conducted by the New Jersey Department of Health and the U.S. Atomic Energy Commission to study the health effects of radium on workers and technicians.

In 1970, the various studies of radium-dial painters by the State of New Jersey, the U.S. Atomic Energy Commission, the Massachusetts Institute of Technology, and New York University were consolidated under the Argonne National Laboratory's Center for Human Radiobiology. Some of these workers are still being studied.

In 1978, the New Jersey Department of Environmental Protection (NJDEP) was notified that EPA had identified the former U.S. Radium Corporation facility in Orange, New Jersey, as a potential hazardous waste site.

In March 1979, the NJDEP Bureau of Radiation Protection conducted a radiation survey of the U.S. Radium site. The results of the survey indicated that a detailed investigation of the site was necessary.

In May 1979, BRP performed a quantitative gamma radiation survey of the site, and in June, a long-term gamma radiation monitoring program was initiated. During these investigations, BRP collected soil samples in the two adjacent vacant lots on Alden Street and along a railroad right-of-way. BRP also began a radon and radon progeny monitoring program at that time. Results of these investigations are presented in Chapter 3.

In November 1979, all owners and leasees of property at the High and Alden Streets site were requested to cooperate with the New Jersey Department of Health in an epidemiological study of their employees. One of the leasees of property at the site, T&E Industries, began its own investigation in January 1980.

In 1982, the U.S. Radium Corporation site, including satellite properties associated with radium processing and handling, was placed on the federal Superfund National Priorities List. In December 1982, Leslie and Barbara

Zwain and their companies, Zip Parcel and Messenger Service and Buzz-Us, took court action against Safety Light Corporation, corporate successor to U.S. Radium, for decontamination of their properties or relocation of their companies.

Early in 1983, Safety Light Corporation retained Dames & Moore, an engineering consulting firm, to prepare a study of remedial measures necessary to bring the High and Alden Street location into compliance with applicable federal and state laws (NUS, 1984). In May 1983, the City of Orange notified EPA of its intent to proceed with a privately commissioned cleanup of the High and Alden Street site. The City requested authorization to proceed on the basis that funds would be reimbursed under Superfund (Shain, 1983). In July of 1983, EPA responded to the City, stating that it intended to identify parties responsible for the contamination at the U.S. Radium site and thus obtain privately financed cleanup. It was noted that the development of a Remedial Action Master Plan (RAMP) had recently been authorized. Therefore, EPA could not authorize the City of Orange to undertake any action on the High and Alden Street site at that time (Thomas, 1983).

On July 19, 1983, BRP conducted a radiation survey of two satellite sites, [redacted] Street and [redacted] Avenue.

On October 4, 1983, EPA notified Safety Light Corporation that it had been identified as a potentially liable responsible party in the investigation of the U.S. Radium site under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). EPA requested a response outlining the activities Safety Light would be willing to undertake. Safety Light responded that an investigation had been completed by Dames & Moore, which was then preparing a site remediation plan (Dughi, 1983).

In November 1983, Resource Applications Incorporated (RAI), under subcontract to NUS Corporation's Remedial Investigation Office, prepared a RAMP for the High and Alden Streets site. This RAMP was to serve as a basis for the eventual development of a work plan outlining the initial remedial measures and the RI/FS for the site (RAI, 1983).

In January 1984, BRP initiated a new phase of monitoring of the properties surrounding the High and Alden Streets site. This monitoring investigation included indoor and outdoor surface gamma surveys and radon sampling of approximately 30 area homes.

In May 1984, EPA requested NUS Corporation, the field investigation team contractor, to prepare a RI/FS Work Plan for the U.S. Radium Corporation site. The final work plan was submitted in August 1984.

In December 1984, Dames & Moore, the consulting firm for Safety Light Corporation, was instructed by EPA to prepare an RI/FS Work Plan proposal for the U.S. Radium site. The final proposal was submitted to EPA in January 1985, and after review was rejected as inadequate (Feldman, 1985).

In September 1985, EPA authorized Camp Dresser & McKee Inc. to prepare an RI/FS Work Plan for the U.S. Radium Corporation site.

(DEC118/12)

3.0 NATURE AND EXTENT OF CONTAMINATION

The following sections assess the problem at the U.S. Radium Corporation site and describe the nature of the problem and the nature and extent of the contamination evidenced by existing data. The hazards presented by radiological contamination are discussed in Chapter 4.

3.1 NATURE OF PROBLEM

Elevated levels of gamma and alpha radiation, radionuclides in soils and building materials, and radon and radon progeny in air have been identified at the High and Alden Streets site in Orange, New Jersey. The resulting exposures often exceed radiological standards for the general public. The source of the contamination is materials containing large amounts of radionuclides belonging to the uranium-238 chain. The contamination is the result of radium extraction and refining processes that took place at this location between 1915 and 1926.

Measurements at several properties adjacent to the site also show elevated levels of gamma radiation and radon and radon daughters. While the levels measured do not exceed the standards for the general public, they are high enough to suggest that radiologically contaminated material may be present. Contamination at these locations may have been carried from the High and Alden Streets site by wind or by persons living near the site.

Additional properties away from the High and Alden Streets site (satellite properties) have shown levels of gamma radiation and radon and radon daughter concentrations that approach and sometimes exceed criteria for unrestricted use by the general public. The source of contamination at these properties has not been characterized, but may result from the use of compounds containing purified radium. Documentary evidence has linked several of the properties to U.S. Radium Corporation activities.

The principal contaminants of concern are radium-226 and its decay product, radon-222. The other members of the uranium-238 decay chain (uranium-238, uranium-234, and thorium-230) are also present in elevated concentrations.

3.2 NATURE OF CONTAMINANTS

Members of the uranium-238 decay series (Figure 3-1) occur naturally throughout the earth's crust and, to some extent, are dissolved in surface and ground water and are suspended as particles in the air. In combination with other natural radiation sources, they produce background radiation that may vary between locations. In natural deposits, the member elements of the decay series occur in definite proportions, known as "secular equilibrium." An unusually high concentration of a decay series or a large deviation in the equilibrium between its members indicates the presence of a man-made deposit.

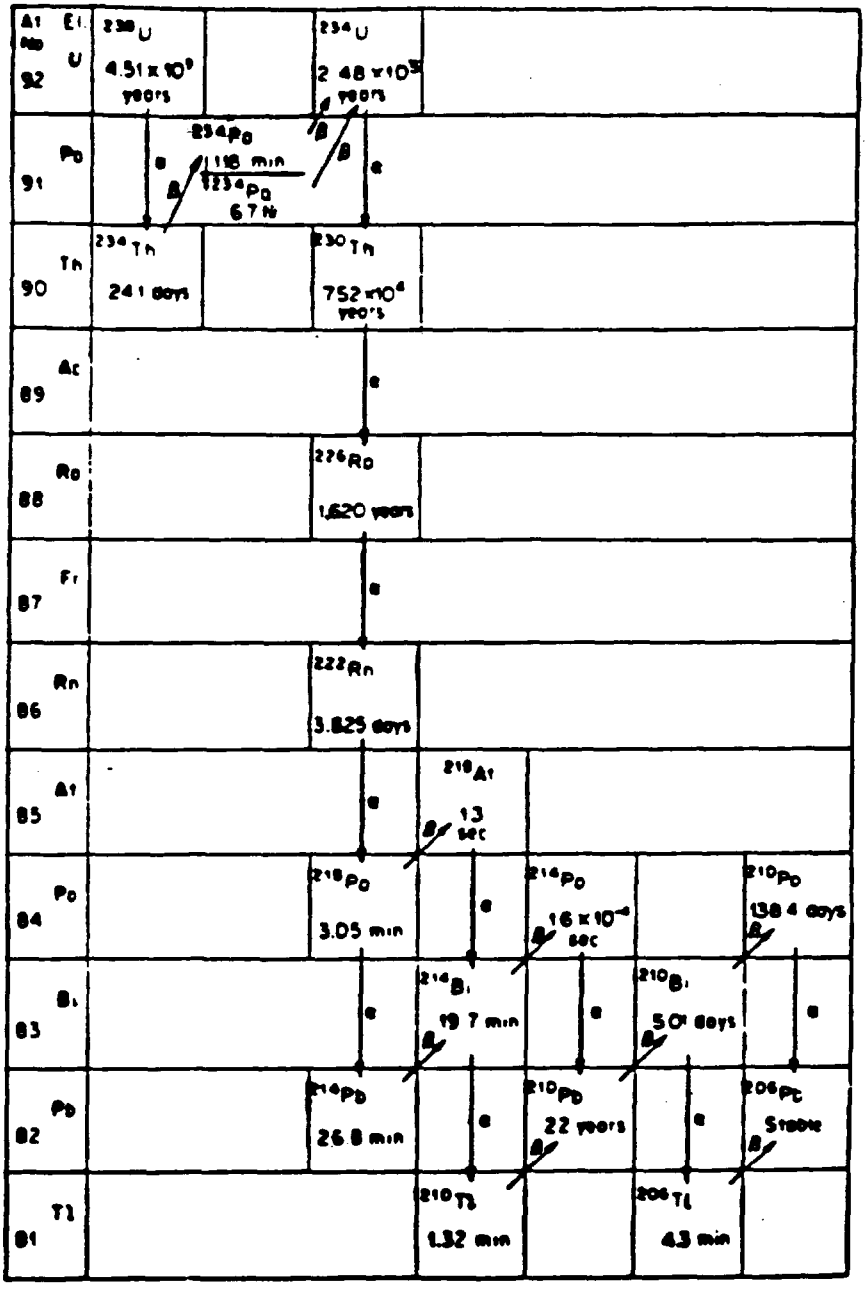
3.2.1 RADIOACTIVE DECAY

Radionuclides are elements whose nuclei change spontaneously, emitting energy. The tendency of an element to change in this way is called radioactivity. The energy emitted is radiation, which may be in the form of charged particles (alpha or beta) or high-energy electromagnetic radiation (gamma).

After the emission of an alpha or beta particle, the original atom is transformed into an atom of a different element, called a "daughter." A series of daughters descended from a single radionuclide is referred to as "progeny". Radioactive decay ultimately results in a stable, nonradioactive isotope, such as lead-210.

Radionuclides have three distinct characteristics that help identify them:

Half-life: The time required for half of the original number of atoms to decay is constant.



Source: Sawyer, C.N. and McCarty, P.L.

FUNDAMENTALS OF CHEMISTRY FOR ENVIRONMENTAL ENGINEERS
McGraw-Hill, N.Y. 1978.

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Figure 3-1
U.S. Radium Corporation Site
URANIUM-238 DECAY SERIES

Type of radiation: A specific radionuclide will always emit the same proportions of alpha, beta, and gamma radiation.

Energy: The radiation emitted by a specific radionuclide will always have the same energy.

Although a radionuclide will always have the same characteristics, other radionuclides may duplicate one or more of them.

3.2.2 ROUTES OF MIGRATION

Salts of radium, uranium, and thorium are water soluble, as is their decay product, radon. Their migration is limited by the availability of water to act as a carrier. Radon, a chemically unreactive gas, will readily diffuse from solution to the atmosphere or to pore spaces within the soil. A deposit of radium-contaminated material can potentially affect the quality of soil, ground water, surface water, and air.

- Contaminated soil presents a gamma radiation exposure hazard and is a source of contamination to ground water, surface water, and air. There is a potential for radionuclides to be taken up by vegetation. The pore spaces in soil can also allow migration of radon gas.

- Ground water will leach radionuclides from soil and can carry them away from their source. There is a potential for contamination of drinking water if the ground water aquifer is used for drinking water supplies. Ground water can also act as a vehicle for radon gas.

- Surface water can receive radionuclides from ground water and from runoff from contaminated land.

- Air may carry contaminated soil particles, radon gas, or particulates with radon progeny.

3.2.3 UNITS OF MEASURE

This section defines the radiological units of measure used throughout Chapter 3. These and other relevant units are discussed further in Section 4.1.

Radionuclides: The concentration of a radionuclide in soil is measured in terms of its activity per weight of dry soil. The activity units used are picocuries per gram (pCi/gm). The concentration of an isotope in water or air is measured in picocuries per liter (pCi/l).

Gamma Radiation: Radiation exposure in air is measured in roentgens (R), milliroentgens (mR), or microroentgens (uR). Radiation dose is measured in rems, millirems (mrem), or microrems (urem). For gamma radiation, 1 roentgen equals 1 rem. Therefore, a gamma radiation rate of 1 uR/hr on a gamma survey instrument calibrated to the specific energy field of the gamma source at the site equals a dose of 1 urem/hr.

Alpha Emission: Radium-226 decays to the gas radon-222 that, in turn, decays to short-lived particles called progeny. Radon progeny become attached to particulates suspended in the air, which can be inhaled and trapped in the bronchial passageways. From a public health viewpoint, these radioactive particles are chiefly important as alpha emitters. Alpha particles are strongly ionizing and, although only effective over a very short distance, impart the greatest damage to the tissue.

Radon progeny exposure is measured in terms of working levels (WL). This unit is employed because of the difficulties inherent in characterizing the complex mixtures of radon progeny present under different circumstances. One working level equals 100 pCi/l of radon-222 in 100 percent equilibrium with its progeny.

3.3 HIGH AND ALDEN STREETS SITE WITH VICINITY PROPERTIES

The following sections describe the extent of contamination at the former radium processing site at High and Alden Streets and at the adjacent properties. This description is based on the site investigations conducted by the EPA REM II contractor on December 10 through 12, 1985 (Appendix A) and on the following reports:

Eng, Jeannette. December 1980. Investigation of a Former Radium Processing Site. Bureau of Radiation Protection, New Jersey Department of Environmental Protection.

Dames & Moore. September 9, 1983. Investigation of a Former Radium Processing Site in Orange, New Jersey.

NUS Corporation, Superfund Division. August 7, 1984. Work Plan for Remedial Investigation/Feasibility Study of U.S. Radium Site, City of Orange, Essex County, New Jersey.

3.3.1 AIR

Radon and Radon PROGENY Concentrations

Air is the medium of transport for radon gas resulting from the decay of radium in the soil or in the buildings themselves. Radon gas generated near or under buildings can infiltrate openings in floors, underground pipes, or any other area where air flow exists. Elevated levels of radon gas will be found in buildings where such conduits lead to well-sealed rooms or where the buildings themselves have been contaminated with radium.

Long-term monitoring of radon levels and radon progeny concentrations (RDC) at the High and Alden Streets site was conducted by BRP from June 1979 through May 1980 (Eng, 1980). Monitoring originally focused on

Buildings D, F, and G, but was expanded during the monitoring period to include buildings A, B, and C. During this period, all buildings on the site, except for D, were occupied by businesses which operated at least 40 hours per week. Figure 3-2 shows the locations of the sampling points for these measurements. Table 3-1 shows the ranges of monthly concentrations measured at each location and the weighted average concentrations for the monitoring period.

The weighted average measurements obtained during the monitoring program met or exceeded the nonoccupational level of 3.0 pCi/L for radon (10 CFR 20) and 0.02 WL (including background) for radon progeny (40 CFR 192 (a)(2)(ii). The averages in the rear of Building G exceeded the levels of 30 pCi/L and 0.33 WL established for radiation workers.

Some remedial measures were implemented in Building F during the monitoring period. These measures are described in Section 3.5.

During the spring and early summer of 1983, Dames & Moore (D&M, 1983) analyzed short-term air samples taken in Buildings F and G for concentrations of radon and radon progeny . No additional remedial measures had been implemented between the end of the BRP investigation and the time of D&M's sampling, and both businesses were still in operation. The results of the D&M sampling (Table 3-2) confirm that radon and radon progeny concentrations exceed established levels for workers, as discussed above. As the samples collected by D&M were of short duration and were all taken within a few months of each other, the results of the BRP investigation should be considered as more representative of conditions in Buildings F and G. The values obtained in Building F while the ventilation system was operating still show radon and radon progeny concentrations exceeding the established levels.

The investigation conducted for EPA by its REM II contractor from December 10 through 12, 1985 (Appendix A) collected grab samples of air in Buildings A, F, and G for radon and RDC analysis. The results are shown in Table 3-3. RDC measurements for Buildings A and G are in the same range as those obtained by BRP and D&M.

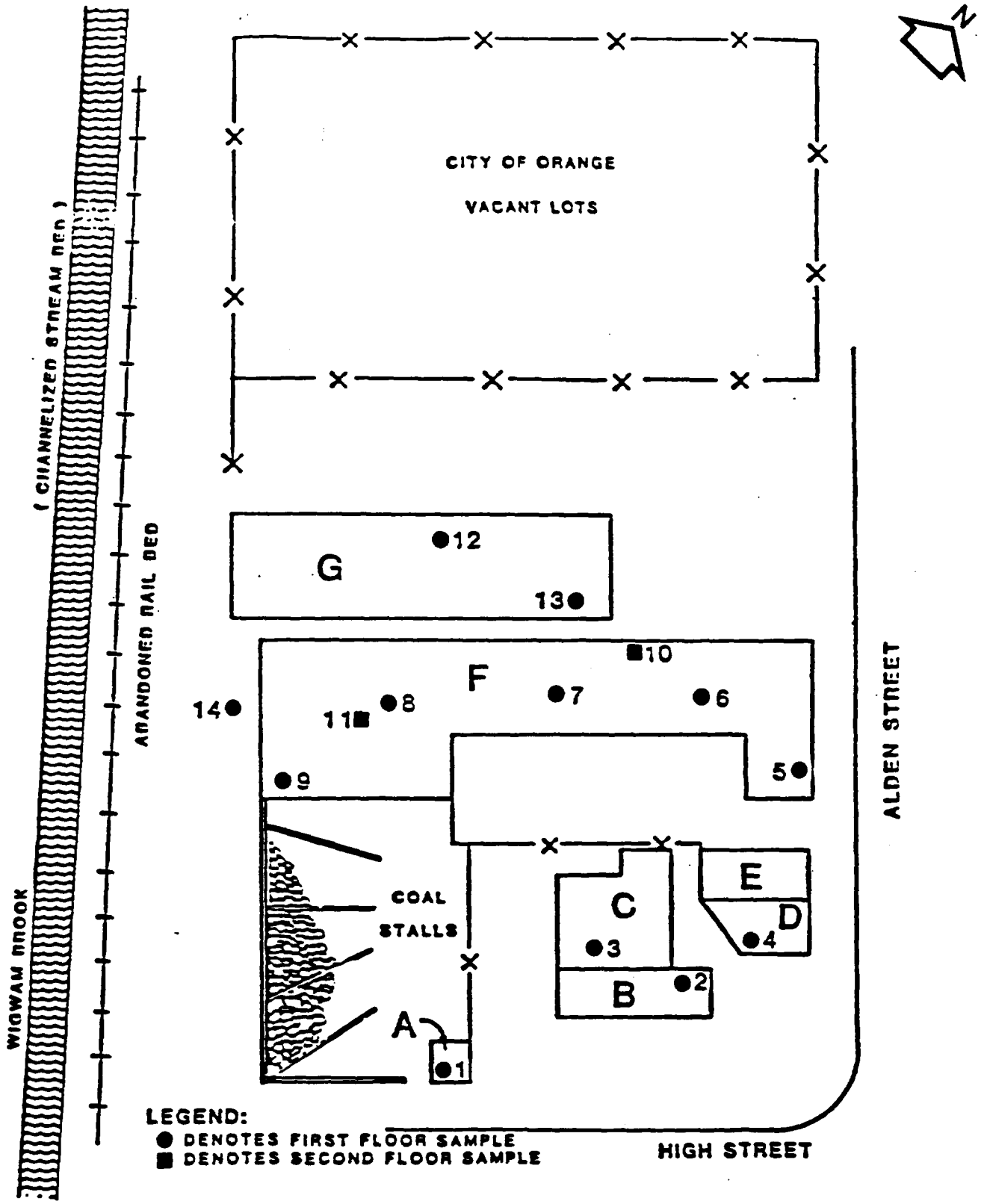

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FIGURE 3-2
U.S. Radium Corporation Site
SAMPLING MAP FOR TLD, RADON & RADON PROGENY MONITORS
HIGH AND ALDEN STREET SITE

TABLE 3-1

LONG TERM RADON AND RADON PROGENY
MEASUREMENTS: RANGES AND WEIGHTED AVERAGES
HIGH AND ALDEN STREETS SITE
JUNE 1979-MAY 1980

Sample Location	Description	Monthly Radon Gas Concentrations (pCi/l)		Monthly Radon Progeny Concentrations (WL)	
		Range	Weighted Average[1]	Range	Weighted Average[1]
1	Building A, on floor in office	2.0 - 4.0	3.1	0.021 - 0.038	0.030
2	Building B	2.0 - 14	7.9	NM[2]	
3	Building C	4.0 - 17	10	NM	
4	Building D	19 - 44	33	0.14 - 0.31	0.22
5	Building F, office area	5.0 - 25	11	0.017 - 0.090	0.062
6	Building F, assembly room near office	15 - 25	17	0.046 - 0.10	0.073
7	Building F, assembly room near oven room	8.0 - 38	21	0.069 - 0.12	0.095
8	Building F, oven room, front	7.8 - 28	18	0.040 - 0.13	0.065
9	Building F, oven room, rear	NM[2]		NM	
10	Building F, second floor above assembly	3.5 - 14	7.4	0.017 - 0.05	0.033
11	Building F, second floor above oven room	2.0 - 6.0	3.2	0.006 - 0.017	0.0094
12	Building G, warehouse area	42 - 70	56	0.47 - 0.90	0.66
13	Building G, office area	13 - 39	28	0.14 - 0.42	0.28
14	Outside of Building F	0.71 - 1.7	1.1	NM	

(Eng, 1980)

1 Weighted Average = $\frac{\sum(\text{Measured Value} \times \text{Duration})}{\sum(\text{Duration})}$

2 NM = No measurement.

(RW21/25)

TABLE 3-2

SHORT-TERM RADON AND RADON PROGENY MEASUREMENTS
DAMES & MOORE INVESTIGATION OF HIGH AND ALDEN STREETS SITE

1983

	Radon (pCi/l)	Radon Daughters (Working Levels)
Building F		
1) Ventilation System On	2.2-28.4 (13.2)	0.002-0.034 (0.016)*
2) Ventilation System Off	12.6-82.5 (49.7)	0.019-0.275 (0.138)
Building G	7.5-55.0 (34.3)	0.133-0.454 (0.285)

* Number in parentheses is an average.

Source: Dames & Moore, September 1983

(RW24/33)

TABLE 3-3

SHORT-TERM RADON PROGENY MEASUREMENTS
HIGH AND ALDEN STREET SITE

	Radon Gas Concentration (pCi/l)	Radon Progeny Concentration (WL)
Building A, office area	4.46	0.019
Building F, rear of oven room	98.4	---[a]
	81.7	0.29
Building G, back storage room	160	2.48
men's room (front of building)	52.8	0.50

[a] Sample exceeded holding time

(RW26/8)

The value obtained in the back storage room of Building G is the highest obtained in any area on site. This room contains material found in the building when the current owner took possession and had been closed for an undetermined time before the sample was taken. Building F had been unoccupied since July 1985. Ventilation was tied into the heating system, which only turns on when the temperature inside the building is below 55°F. The measured RDC level is greater than that measured by BRP or D&M.

In January 1984, BRP initiated an investigation of properties in the immediate vicinity of the former radium processing site (NUS, 1984). Radon concentrations were measured with activated carbon canisters over a three-day period. Results are tabulated in Table 3-4. An indexed map is provided as Figure 3-3. The average radon concentrations in each building are below the criterion of 3.0 pCi/l recommended in 10 CFR 20 as a maximum for habitable structures. No indoor RDC measurements or any outdoor measurements were made.

Suspended Particulates

Particulate concentrations in air have not been measured inside buildings or outdoors for the High and Alden Streets site or its vicinity properties.

Gamma Radiation

Both gamma radiation surveys and long-term gamma radiation monitoring were performed by BRP at the High and Alden Streets site in 1979 and 1980.

Results of the gamma survey of the High and Alden Streets site are displayed as Figure 3-4. The isoexposure lines were interpolated between waist-high scintillometer readings taken at intersections of a rectangular grid. A dotted circle on the isoexposure map indicates the location of a reading that was not used or was considered an isolated reading. Scintillometer readings have an accuracy of 10 percent and were rounded off to the nearest decade (10 uR/hr) (Eng, 1980).

The survey revealed extensive areas of elevated gamma radiation, ranging as high as 650 uR/hr. The most elevated readings were generally found outside

TABLE 3-4

SHORT-TERM RADON MEASUREMENTS (pCi/l)

BRP INVESTIGATION OF VICINITY PROPERTIES

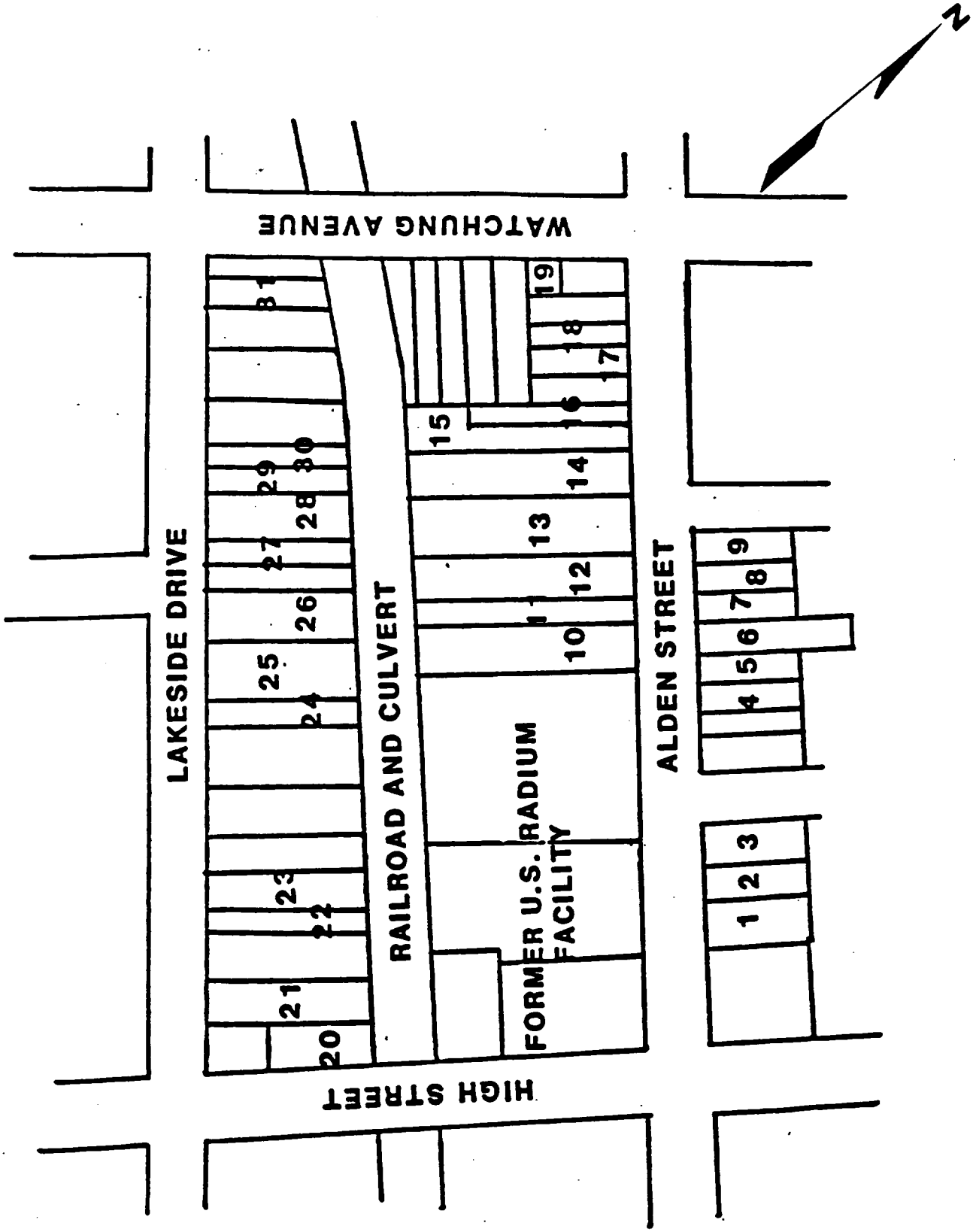
JANUARY 1984

(Refer to Figure 3-3)

Property Number	Basement	First Floor	Second Floor
1	0.42	0.55	
2	1.0	0.87	0.85
3	1.3	0.45	
4	Open Lot		
5	1.1	0.34	
6	Access Denied		
7	2.5	1.2	
8	1.3		0.90
9	1.4		0.53
10	Not Home		
11	0.60	0.59	0.76
12	1.3	0.71	0.73
13	Not Home		
14	1.3	0.72	
15	2.0	0.95	
16	0.75	0.33	
17	1.9	0.34	
18	1.2	0.85	
19	0.40	0.62	0.57
20	1.3/1.5	N/A	
21	1.3		1.0
22	1.0	1.0	
23	0.55	0.40	
24	1.05	0.90	
25	0.40	1.9	
26	1.3	0.50	
27	2.0	0.60	
28	1.1	0.40	
29	1.0	0.60	
30	1.0	0.40	
31	1.3	0.94	

Source: NUS, 1984 (Appendix A)

(RW24/34)



SOURCE: NUS, 1984(Appendix A)

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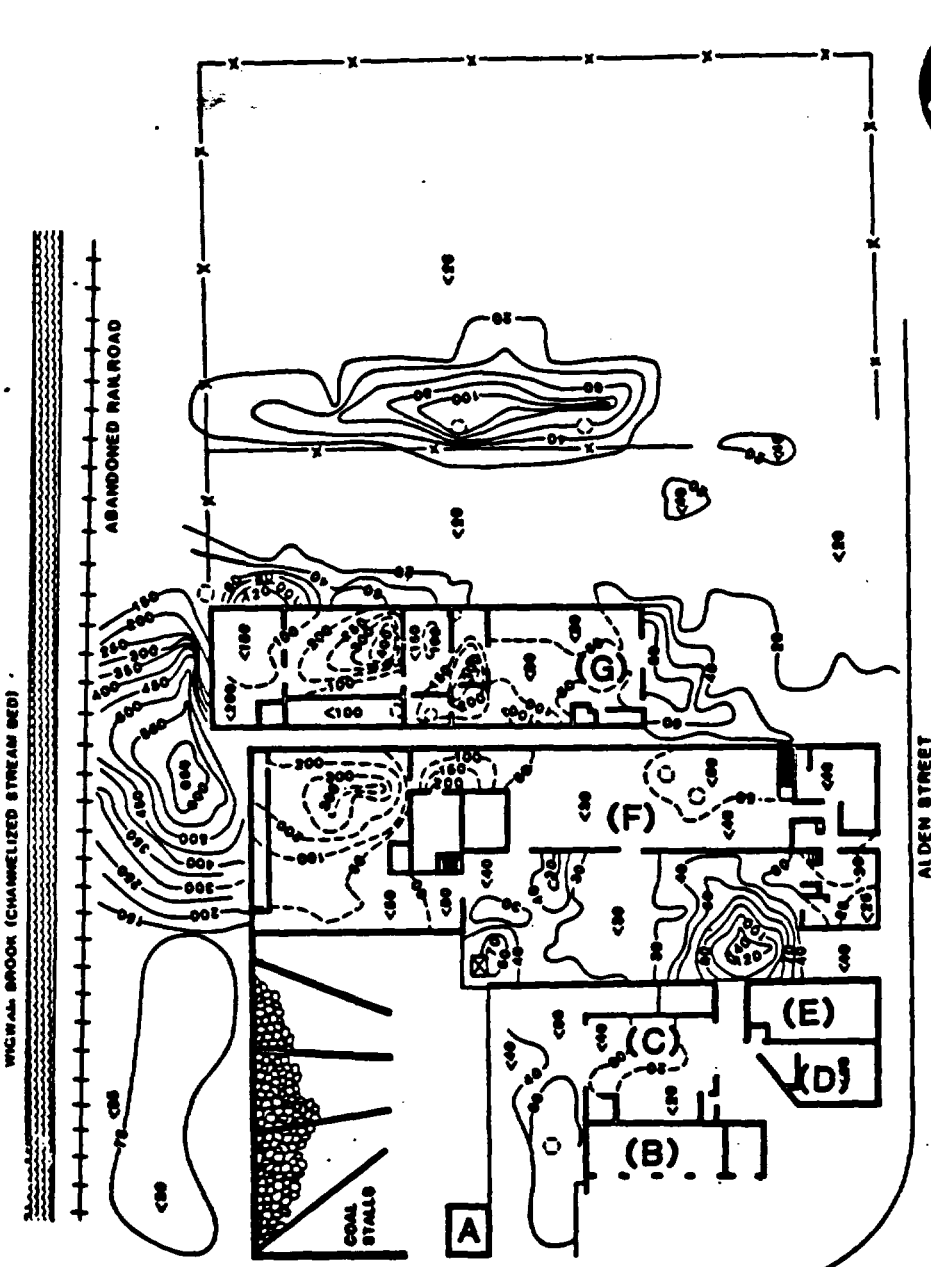
FIGURE 3-3
U.S. Radium Corporation Site
VICINITY PROPERTIES
INVESTIGATED BY NJDEP/BRP



LEGEND:

--- ISOEXPOSURE LINES INSIDE BUILDINGS

—— ISOEXPOSURE LINES OUTSIDE BUILDINGS

ISOLATED HIGH READINGS

20 = GAMMA ISOEXPOSURE RATE IN MICROROENTGEN PER HOUR (μR/hr) AT 1 METER ABOVE GROUND

SOURCE: NUS, 1984

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Figure 3-4

U.S. Radium Corporation Site
GAMMA RADIATION ISOEXPOSURE MAP
HIGH AND ALDEN STREET SITE

of the locations the original U.S. Radium Corporation buildings (Figure 2-2). This finding supports the belief that processing wastes were disposed of on the processing site.

In late April and early May of 1983, Dames & Moore conducted gamma exposure surveys on Buildings F and G and their properties (D&M, 1983). Measurements were again taken at waist height. Buildings A, B, and E and their properties were not surveyed by either BRP or D&M.

The inside of Building C showed readings ranging from background to 40 uR/hr. In the parking lot outside Building C, the average reading was less than 60 uR/hr, with a maximum reading of 260 uR/hr. Readings from the parking lot of Building F indicated contamination in a distinct spot. In the Alden Street side of the parking lot, a maximum value of 140 uR/hr was recorded by BRP. Another localized area in the southern corner of the lot read over 70 uR/hr. D&M measured a maximum exposure of 300 uR/hr in the parking lot of Building F.

The first floor of Building F showed readings well above background. Maximum readings for the Alden Street side (front half of the building) were reported as 60 uR/hr in the BRP study and 100 uR/hr in the Dames & Moore study. The maximum values found in the oven room in the rear of the building were 411 uR/hr (BRP) and 1,000 uR/hr (D&M). The middle section of the second floor, where radium painters formerly worked, showed maximum gamma readings of 110 uR/hr (BRP) and 200 uR/hr (D&M).

The front half of Building G facing Alden Street had readings ranging from 50 to 100 uR/hr. In the rear portion, higher readings were found, with maximums reaching 400 uR/hr (BRP) and 700 uR/hr (D&M). Outdoor surface gamma measurements show that radiation on the property immediately in front of Building G is above background, ranging from 20 uR/hr to a maximum of 250 uR/hr (400 uR/hr in the D&M study) near the front left corner of the building. Near the rear of the same building, readings ranging up to 120 uR/hr were measured. Along the interior fence dividing the property from the adjacent vacant lots, readings up to 100 uR/hr, with a maximum of 200 uR/hr, were found.

The highest outdoor surface gamma readings were found behind Buildings F and G near the railroad tracks. The maximum readings of 650 uR/hr (BRP) and 1,000 uR/hr (D&M) were found in this area.

The survey measurements obtained by Dames & Moore were all roughly twice as great as those obtained by BRP. The differences probably were due to instrument calibrations. The BRP results are supported by onsite readings taken by BRP using a pressurized ionization chamber, results of long-term radiation monitoring performed by BRP, and gamma exposure rate measurements made by EPA's REM II contractor.

Measurements taken by EPA's REM II contractor in Buildings G and A are discussed in Appendix A. Measurement locations are shown in Appendix A. One measurement was made in Building F, at the rear of the oven room. The gamma exposure rate in that area exceeded 630 uR/hr. Waist-high measurements in Building G ranged from 25 uR/hr to 456 uR/hr, with a maximum contact reading of 646 uR/hr. The distribution of the readings supports the results of the BRP investigation.

Exposure rates in Building A ranged from 58 uR/hr to 141 uR/hr, with the highest readings found by the entrance to the inner office. The areas of the building where most of the office manager's time is spent showed exposure rates between 70 and 80 uR/hr. Exposure rates in the storage shed at the rear of the building were generally near 93 uR/hr. Measurements taken at the center of the shed and the entrance to the shed were higher: 144 and 287 uR/hr, respectively.

Long-term gamma radiation monitoring was conducted by BRP at the High and Alden Streets site. Figure 3-2 shows the location of the sampling points for these measurements. Table 3-5 shows the ranges and weighted averages of long-term gamma radiation measurements for each location.

Measurements were made with thermoluminescent dosimeters (TLD) placed approximately 1.5 meters above the floor. The highest TLD measurement in Building F was 195 uR/hr, found in the oven room. The warehouse area of Building G has a maximum, based on monthly measurements, of 162 uR/hr.

TABLE 3-5

LONG TERM GAMMA MEASUREMENTS: RANGES
BRP INVESTIGATION OF HIGH AND ALDEN STREETS SITE
JUNE 1979 - MAY 1980

Sample Location	Description	Monthly Gamma Exposure Rates from TLD's (uR/hr)	Average Long-Term Exposure Rate (uR/hr)
1	Building A	47.3 - 69.2	61.0
2	Building B	15.8 - 26.3	20.8
3	Building C	16.3 - 27.9	21.0
4	Building D	15.3 - 20.1	18.1
5	Building F, office area	17.2 - 25.1	21.1
6	Building F, Assembly room near office	33.6 - 69.8	54.2
7	Building F, Assembly room near oven room	25.8 - 41.5	33.7
8	Building F, Oven room, front	121.0 - 194.9	154.4
9	Building F, Oven room, rear	31.8 - 142.6[b]	81.2[b]
10	Building F, Second floor above assembly	62.4 - 93.1	80.5
11	Building F, Second floor above oven room	46.3 - 76.0	57.6
12	Building G, Warehouse area	148.8 - 162.3	152.4
13	Building G, Office area	33.6 - 45.7	40.3
14	Outside of Building F	NM	NM

[a]NM = No measurement.
[b]Location of TLD was changed during monitoring period.

(RW24/35)

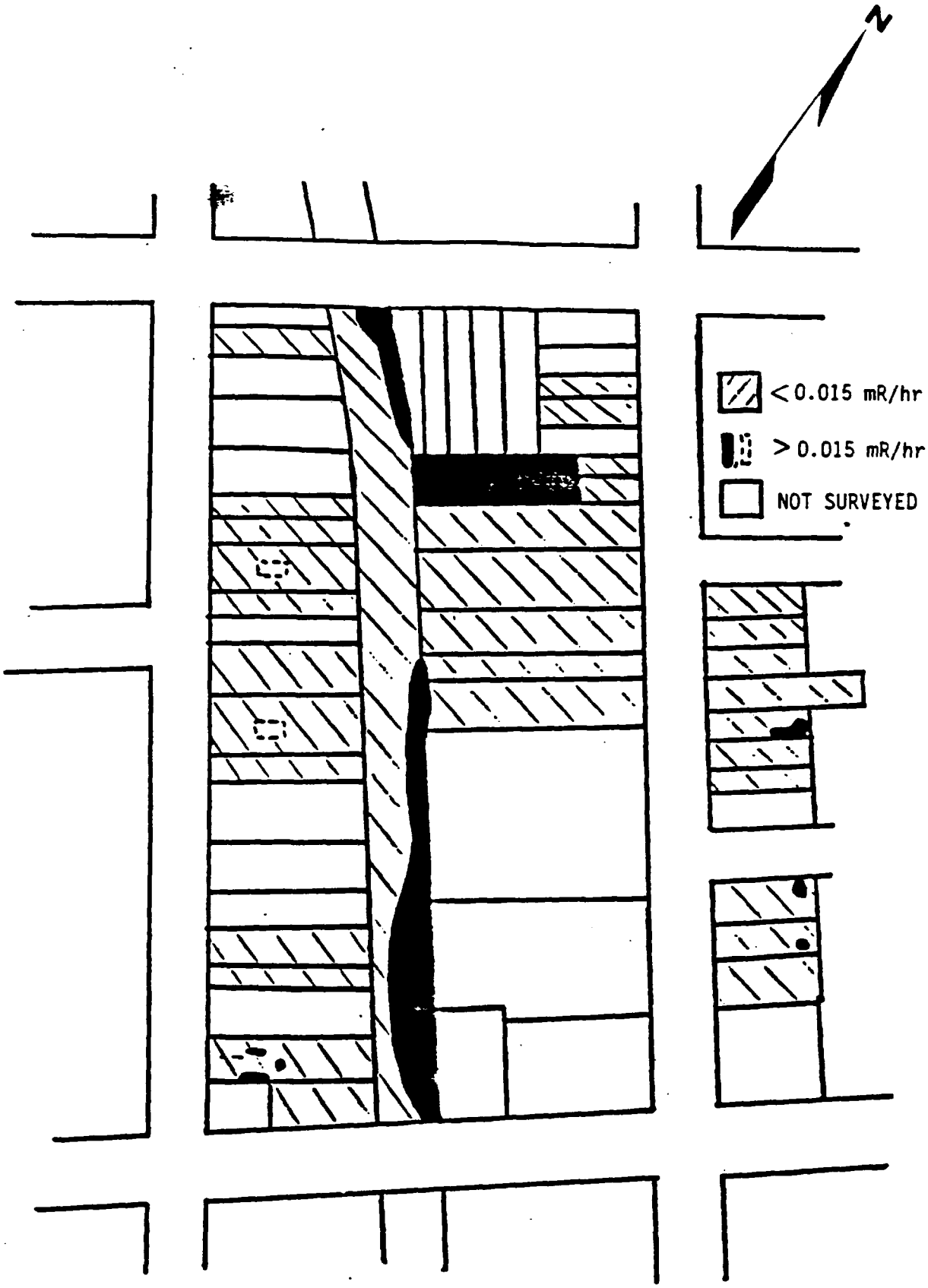
The long-term average exposure rate in Building A was measured at 61 uR/hr. Buildings B, C, and D showed long-term average exposure rates of approximately 20 uR/hr each.

In January 1984, BRP measured gamma exposure rates at 31 properties in the immediate vicinity of the High and Alden Streets site (NUS, 1984). Scintillometer readings were taken at one meter above ground at various locations throughout each property and inside any structures on each property.

Only two homes (indexed as 25 and 28) had interior gamma exposure rates greater than background levels. One basement had a single hot spot that measured 25 uR/hr. The other elevated gamma exposure rate originated from a set of wooden stairs (up to 30 uR/hr). These stairs were once part of one of the structures at the processing facility and were taken by the homeowner when the structure was razed. It is not reported that the stairs were ever removed from the home or decontaminated. The report of the BRP investigation (NUS, 1984) did not identify which building had either exposure anomaly. Neither house had elevated outdoor gamma radiation.

Elevated external gamma exposure rates were found on six properties. The maximum measurement was 50 uR/hr. The extent of contamination was limited to small areas on four properties but was extensive on property numbers 15 and 16 where the entire backyard exhibited elevated exposure rates. Figure 3-5 depicts the locations of the elevated readings, and Table 3-6 lists the gamma exposure rates by property. A keyed map of the surveyed area is presented as Figure 3-3.

Gamma measurements were also taken along the abandoned railroad spur and the culvert for Wigwam Brook. Exposure rates were highest behind the former processing facility, ranging from 20 to 600 uR/hr. Behind the open lots next to the former radium-processing plant, the measurements ranged from 10 to 30 uR/hr. Other elevated regions were found near Watchung Avenue, ranging up to 45 uR/hr, and behind property numbers 10 and 11, where the maximum exposure rate was 25 uR/hr.



SOURCE: NUS, 1984(Appendix A)

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FIGURE 3-5
U.S. Radium Corporation Site
VICINITY PROPERTIES OUTDOOR GAMMA EXPOSURE RATES

TABLE 3-6

SHORT-TERM GAMMA EXPOSURE MEASUREMENTS (mR/hr)

BRP INVESTIGATION OF VICINITY PROPERTIES

JANUARY 1984

(Refer to Figure 3-3)

Property Number	Maximum	Range
1	<0.012	-
2	0.025(1)	0.010 - 0.025
3	0.040(1)	0.010 - 0.040
4	<0.012	-
5	0.030(1)	0.010 - 0.030
6	<0.012	-
7	<0.012	-
8	<0.012	-
9	<0.012	-
10	<0.012	-
11	<0.012	-
12	<0.012	-
13	<0.012	-
14	<0.012	-
15	0.050(1)	0.010 - 0.050
16	0.050(1)	0.010 - 0.050
17	<0.012	-
18	<0.012	-
19	<0.012	-
20	<0.012	-
21	0.050(1)	0.010 - 0.050
22	<0.012	-
23	<0.012	-
24	<0.012	-
25	0.030(2)	0.010 - 0.030
26	<0.012	-
27	<0.012	-
28	0.025(2)	0.010 - 0.025
29	<0.012	-
30	<0.012	-
31	<0.012	-

(1) Outdoor measurements

(2) Indoor measurements

Source NUS, 1984 (Appendix A)

(RW24/36)

3.3.2 SOILS AND BUILDING MATERIALS

Radiochemical Analyses

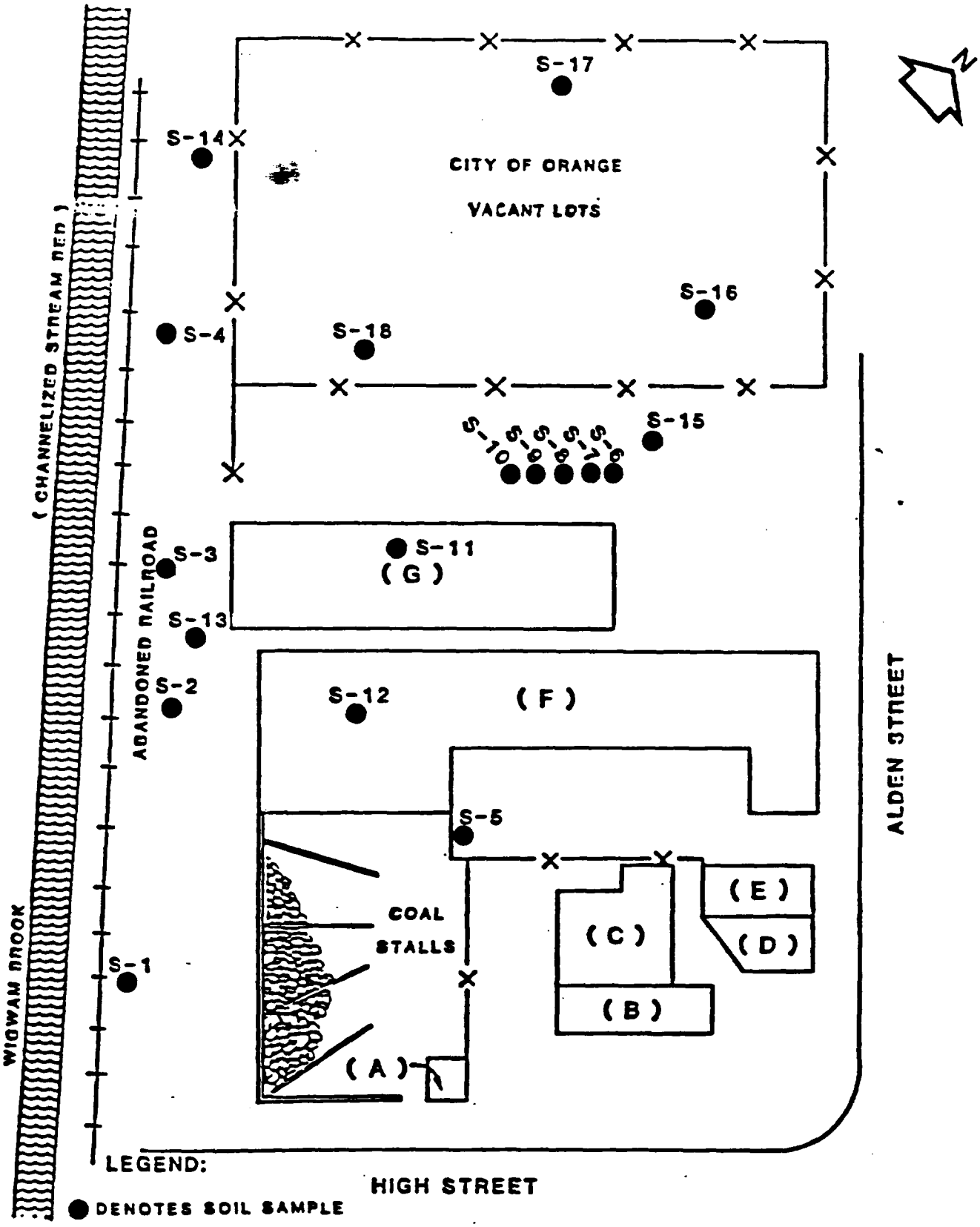
Soil samples were collected throughout the BRP investigation. Several samples of concrete and cement chips from contaminated floor areas in Buildings F and G were also collected. Sample locations are indicated in Figure 3-6. Table 3-7 provides the results of soil sample analyses for radium-226 and isotopes of thorium and uranium and gives geologic descriptions, when available (Eng, 1980). Concrete and cement chips were not analyzed quantitatively, other than to determine whether radium-226 was present in concentrations above background.

All samples, except S-4 and S-18, showed concentrations of radium-226 above EPA criteria in 40 CFR 192. These regulations state that the concentration of radium-226 in soil, averaged over the first 15 cm of soil below the surface, shall not exceed the background level by more than 5 pCi/g, and for the next 15 cm of soil and each successive 15-cm layer beneath it, the concentration should not exceed 15 pCi/g. Radium concentrations as high as 3,299 pCi/gm were detected in soil samples taken beneath the T&E building.

Ten of the samples were sent to EPA's Eastern Environmental Radiation Facility for radiochemical analysis of radium, uranium, and thorium isotopes. Every sample analyzed showed the presence of uranium and thorium isotopes from the uranium-238 decay series in addition to radium-226. Uranium-235 and thorium-232 and their decay products were also detected. Concentrations of radium-226 and thorium-230 were extremely variable relative to the other isotopes found in the samples.

Three core samples taken by BRP in July 1979 showed radium contamination and nonvirgin material as deep as 50 inches. An independent auger-hole study found radium contamination down to about 90 inches (Steidley, 1981). This is the maximum depth of contamination found on site to date.

No samples of soil or building materials have been collected from any of the properties in the vicinity of the High and Alden Streets site.



REF: NUS, 1984

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FIGURE 3-6
U.S. Radium Corporation Site
SOIL SAMPLE LOCATION MAP
HIGH AND ALDEN STREET SITE

TABLE 3-7
SOIL SAMPLE RESULTS
BRP INVESTIGATION OF THE HIGH AND ALDEN STREETS SITE
(Refer to Figure 3-6 for Sampling Locations)
(Source: Eng , 1980)

Sample Location (Sample Number)	Description	Ra-226 Concentration (pCi/gm)	Additional Analyses (pCi/gm)
S-1 (26074)	Surface (0"-3")	14 +/- 3	
S-2 (26075)	Surface (0"-3")	248 +/- 12	
S-3 (26076)	Surface (0"-3")	670 +/- 30	
S-4 (26079)	Surface (0"-3")	1.07 +/- 0.11	U-234 0.289 +/- 19% Th-227 0.153 +/- 34% U-235 0.022 +/- 59% Th-228 0.156 +- 27% U-238 0.302 +/- 19% Th-230 0.973 +/- 10% Th-232 0.222 +/- 20%
S-5 (26079)	Surface (0"-3")	470 +/- 20	
S-6 (26621)	Surface (0"-12")	6.4 +/- 0.8	
S-7 (26622)	Surface (0"-12")	6.7 +/- 0.6	
S-8 (26623)	Surface (0"-12")	9.5 +/- 0.6	
S-9 (26624)	Surface (0"-12")	49 +/- 2	
S-10 (26625)	Surface (0"-12")	3.2 +/- 2	U-234 9.665 +/- 11% Th-227 3.348 +/- 8% U-235 0.562 +/- 16% Th-228 1.169 +/- 9% U-238 9.005 +/- 11% Th-230 35.46 +- 3% Th-232 1.474 +/- 8%

TABLE 3-7 (continued)
SOIL SAMPLE RESULTS
BRP INVESTIGATION OF THE HIGH AND ALDEN STREETS SITE
(Refer to Figure 3-6 for Sampling Locations)
(Source: Eng., 1980)

Sample Location (Sample Number)	Description	Ra-226 Concentration (pCi/gm)	Additional Analyses (pCi/gm)	
S-11 (27128)	Core (0"-15") New concrete	23.9 +/- 1%	U-234 11.36 + 10% U-235 0.66 +/- 14% U-238 12.29 +/- 10%	Th-227 1.01 +/- 12% Th-228 0.97 +/- 8% Th-230 12.42 +/- 4% Th-232 0.97 +/- 9%
S-11 (27129)	Old Concrete	6.4 +/- 3%	U-234 8.66 +/- 10% U-235 0.60 +/- 15 U-238 9.14 +/- 10%	Th-227 0.56 +/- 15% Th-228 0.59 +/- 11% Th-230 4.93 +/- 5% Th-232 0.43 +/- 12%
S-11 (27130)	Black Granular Material	Detected, not quantified		
S-11 (27131)	Concrete	216.3 +/- 1%	U-234 116.0 +/- 12% U-235 9.98 +/- 12% U-238 130.9 +/- 12%	Th-227 7.75 +/- 5% Th-228 1.92 +- 6% Th-230 85.07 +/- 3% Th-232 1.72 +/- 7%
S-12 (27132)	Cement chips, existing concrete floor, 0"-6" depth Gamma Reading: 0.05 mR/hr	0.96 +/- 8%	U-234 1.58 +/- 12% U-235 0.13 +/- 24% U-238 1.72 +/- 12%	Th-227 0.20 +/- 27% Th-228 0.63 +/- 11% Th-230 0.82 +/- 10% Th-232 0.32 +/- 15%
S-12 (27133)	Similar to above, 0"-6" depth Gamma Reading: 0.05 mR/hr	0.77 +/- 9%	U-234 0.44 +/- 15% U-235 0.08 +/- 31% U-238 0.51 +/- 14%	Th-227 0.17 +/- 29% Th-228 0.49 +/- 12% Th-230 0.46 +/- 13% Th-232 0.364 +/- 14%

TABLE 3-7 (continued)
SOIL SAMPLE RESULTS
BRP INVESTIGATION OF THE HIGH AND ALDEN STREETS SITE
(Refer to Figure 3-6 for Sampling Locations)
(Source: Eng , 1980)

Sample Location (Sample Number)	Description	Ra-226 Concentration (pCi/gm)	Additional Analyses (pCi/gm)
S-12 (27138)	Fine to medium quartz sand, lumps of white clay, 18"-24" depth Gamma Reading: 10.0 mR/hr	3299 +/- 0.8%	U-234 557.9 +/- 11% Th-227 160.2 +/- 17% U-235 37.72 +/- 22% Th-228 17.80 +/- 46% U-238 557.2 +/- 11% Th-230 1392 +/- 5% Th-232 9.016 +/- 49%
S-12 (27139)	Soil, 24"-30" depth	2670 +/- 130	
S-12 (27140)	Slightly clayey, silty sand, clay lumps, 30"-36" depth Gamma Reading: 8.0 mR/hr	2090 +/- 1%	U-234 1237 +/- 11% Th-227 98.29 +/- 21% U-235 82.89 +/- 15% Th-228 2.954 +/- 18% U-238 1276 +/- 11% Th-230 1639 +/- 4% Th-232 8.295 +/- 50%
S-12 (27142)	White clay lumps, slag, debris, 42"-50" depth Gamma Reading: 3.0 mR/hr	2610 +/- 130	
S-13 (27143)	Medium sand, greenish gray, 0"-12" depth Gamma Reading: 0.1 mR/hr	592 +/- 0.6%	U-234 101.4 +/- 11% Th-227 59.92 +/- 8% U-235 6.253 +/- 19% Th-228 3.136 +/- 28% U-238 91.38 +/- 12% Th-230 656.3 +/- 3% Th-232 4.012 +/- 21%
S-14 (26978)	Surface soil, 0"-3" depth	5.7 +/- 0.4	
S-15 (24917)	Surface soil, 0"-3" depth	5.3 +/- 0.4	

TABLE 3-7 (continued)
SOIL SAMPLE RESULTS
BRP INVESTIGATION OF THE HIGH AND ALDEN STREETS SITE
(Refer to Figure 3-6 for Sampling Locations)
(Source: Eng . 1980)

Sample Location (Sample Number)	Description	Ra-226 Concentration (pCi/gm)	Additional Analyses (pCi/gm)
S-16 (24916)	Subsurface soil, taken beneath blacktop, 0"-3" depth	8.9 +/- 0.6	
S-17 (24950)	Subsurface soil, taken beneath blacktop, 0"-3" depth	2.0 +/- 0.7	
S-18 (24918)	Subsurface soil, taken beneath blacktop, 0"-3" depth	1.5 +/- 0.4	
(RW16/32)			

Surface Alpha Contamination

Surface alpha scans were performed by the REM II team at Buildings A, F and G to determine the degree of surface alpha contamination in those buildings. Surface swipes were taken to determine the hazard posed by removable long-lived alpha contamination, presumed to be due to radium residuals. Sampling locations and results are presented in Appendix A.

All swipes taken in Building A and the attached storage shed showed alpha activities within the background range. The readings detected during the surface alpha scan were near 100 dpm/100 sq cm.

Building F presented elevated alpha readings on all surfaces scanned. The general range of activity was 150 to 200 counts per minute (cpm), equivalent to 1,500 to 2,000 dpm/100 sq cm. Many hot spots, ranging from 4,000 to 600,000 dpm/100 sq cm, were encountered. Surface swipes were taken at 10 locations. Swipes were counted the day following the investigation of Building F, allowing any short-lived alpha emitters (radon daughters) present to decay. Two swipes showed elevated levels of removable long-lived alpha emitters. One swipe (number 6) was taken from the top of a radiator at the rear of the second floor. The swipe location read 4,000 dpm/100 sq cm and the swipe itself read 21.3 dpm/100 sq cm. The other swipe was taken from an exposed panel of the inner wall near the front of the second floor. The panel showed alpha radiation readings of over 600,000 dpm/100 sq cm and the swipe read 348 dpm/100 sq cm. Both swipes exceeded the criterion of 20 dpm/100 sq cm set for removable alpha contamination (Table 4-1 Appendix A).

Elevated alpha readings were also detected on all surfaces scanned in Building G. The range over most locations in the building was 2,000 to 3,000 dpm/100 sq cm. Readings ranged up to 26,000 dpm/100 sq cm in the area of the swipe locations numbered 11 and 12. The area of swipes 16 and 17 was also considerably elevated. A total of 9 swipes was taken at locations where alpha activity was elevated above the range typical of the building. After one day, five swipes showed long-lived activities greater

than 20 dpm/100 sq cm. Three of the elevated swipes (11, 12, 17) were taken at an interior wall with window openings that appeared as if it might have been an exterior wall of an older structure. Two of the elevated swipes (16, 18) were taken from shelving that appeared to be older than the rest of the building.

No alpha radiation measurements have been made at any of the vicinity properties.

3.3.3 WATER

Ground Water

There has been no study of ground water movement or quality at the High and Alden Streets site or its vicinity properties.

A single water sample was taken from an unused well in Building F, reported to be approximately 300 feet deep (NUS, 1984). Analysis showed no detectable radium, and gross alpha and gross beta measurements were within the limits of the National Primary Drinking Water Standards (Eng, 1980).

Surface Water and Sediments

The only surface water in the vicinity of the High and Alden Streets site is Wigwam Brook. Water from this brook has not been analyzed for the presence of radionuclides.

Sediments from the natural course of the brook, now below the concrete channel, have not been sampled. Sediments from locations that would receive runoff from the site have also not been analyzed.

3.4 SATELLITE PROPERTIES

Satellite properties have been identified from U.S. Radium Corporation records or from a ground check performed by BRP of an aerial gamma survey overflight made in May 1981. Most of the 20 properties identified to date

are located in the City of Orange, although three are in the City of East Orange and one is in the Village of South Orange. Additional satellite properties may be identified during the RI.

3.4.1 SURVEYS BY BRP

In 1983 and 1984, nine satellite properties were surveyed by BRP for elevated gamma radiation exposure rates and for indoor concentrations of radon or radon progeny. All of these properties presented gamma radiation levels above normal background levels: approximately 10 uR/hr (Eng, 1980). Radon and RDC levels were below concentrations requiring remediation (0.02 WL). As elevated radiation exposures have been confirmed at these locations, further investigation will take place during the RI.

The satellite properties investigated to date by BRP are:

[redacted] Street

In January and April 1984, BRP performed an extensive radiological survey of the buildings at [redacted] and [redacted] Street. The survey included indoor gamma and beta exposure measurements and radon and RDC sampling. In addition, a soil core sample was taken in the basement of [redacted] Street. No ground water or outdoor soil samples or outdoor gamma measurements have been obtained from this property.

[redacted] Street

According to U.S. Ra[redacted]m files, the building at this address was used as a dial-painting facility or as a laboratory. Gamma radiation levels on the first floor were as high as 200 uR/hr on three exposed pipes in the rear stairwell leading to the indoor balcony between the first and second floors. Exposure levels on the second floor ranged from 10 to 20 uR/hr; however, only a portion of this floor was surveyed. Third-floor radiation levels were as high as 100 uR/hr in the front room. No radon, RDC, or soil or ground water samples or gamma measurements have been taken at 350 Main Street.

[redacted]r Street

The outdoor gamma levels range from 10 to 60 uR/hr with the highest radiation levels found along the southwestern side of the property. Indoor levels were 12 uR/hr in the basement and 10 uR/hr on the first floor, considered within the normal background range (NUS, 1984). The indoor radon concentrations measured during the survey were 4.0 pCi/l in the basement and 1.6 pCi/l on the first floor. RDC, soil and ground water samples were not taken at this property.

[redacted]r Street

The gamma radiation exposure rate on the grounds of this property ranges as high as 46 uR/hr near the rear corner of the building. The radiation level inside the building is 12 uR/hr on the first floor. The indoor radon concentrations determined during the BRP investigation were 3.4 pCi/l in the basement and 1.7 pCi/l on the first floor. Investigations at this property have not included RDC, soil, or ground water sampling.

[redacted] Street

The outdoor gamma radiation level at [redacted] Street ranges up to 70 uR/hr at the rear of the property, and indoor rates range from 10 to 12 uR/hr in the basement and on the first floor. The measured concentrations of radon

in the building were 3.5 and 2.0 pCi/l for the basement and first floor, respectively. RDC, soil, and ground water samples have not been taken at this property.

[redacted] Street

The outdoor gamma exposure rates range from 15 to 110 uR/hr and indoor levels range from 10 to 12 uR/hr. Radon concentrations during the survey were 4.0 pCi/l in the basement and 0.6 pCi/l on the first floor. This property has not been sampled for indoor radon progeny concentrations or contamination of soil or ground water.

[redacted] Street

Radiation levels of up to 50 uR/hr were detected during the outdoor gamma survey of this property. The indoor rates range from 10 to 14 uR/hr. The first-floor radon concentration was 0.5 pCi/l, and in the basement the maximum concentration was 2.5 pCi/l. No RDC, soil, or ground water samples were taken at 435 Washington Street.

[redacted] Street

The outdoor gamma rates at [redacted] Street range from 10 to 30 uR/hr and the indoor level is 12 uR/hr. The investigation determined that the indoor radon concentration was 2.8 pCi/l on the first floor and 4.5 pCi/l in the basement. RDC, soil, and ground water samples were not collected at this property.

3.4.2 SURVEYS BY EPA

Preliminary radiological screenings have been performed at four satellite properties by EPA's REM II contractor. An additional two buildings were partially screened, based on their association with a known satellite property. During these screenings gamma exposure rates and surface alpha contamination were measured and surface swipes were taken. Swipes were

analyzed for long-lived removable alpha contamination. Grab samples of air were also collected and analyzed for radon and RDC. The results of the screenings are presented in Appendix B and are summarized bel

The addresses of the satellite properties screened by EPA are:

The addresses of the additional buildings are:

[redacted] Avenue, South Orange

At least one location, in the area between the south wall of the basement and the furnace, showed positive evidence of radiological contamination. Gamma exposure rates in this area measured as high as 290 uR/hr. A single alpha swipe taken from bare concrete on the basement floor showed 9.7 dpm/100 sq cm of long-lived removable alpha radiation. Radon and RDC measurements showed concentrations that were near typical background levels, but these results are not reliable indicators of contamination, because the house's forced-air ventilation system was operating during the sampling.

Further investigation will be needed at this property to determine the source of the elevated gamma radiation exposure and the nature and extent of contamination.

[redacted] Avenue, Orange

Results of the screening at this property suggest that contaminated materials are present in the root cellar at the front of the house and aroun

and under the kitchen in the crawl space at the rear of the house. Some contamination may also be present in the garage at the rear of the property.

Indoor gamma exposure rates up to 212 uR/hr were recorded in the basement wall, next to the root cellar. Elevated readings were also recorded at the opening to the crawl space below the kitchen and in the kitchen, above the crawl space. Slightly elevated long-lived alpha contamination was found on swipes taken at four locations around the basement. Radon and RDC were present at typical background levels.

Further sampling is required at this property to define the extent and degree of radioactive contamination present.

[redacted] Street, East Orange

Results of the survey do not indicate the presence of radioactive materials at [redacted] Street. Gamma exposure rates were within an acceptable range for natural background, with the higher readings attributable to specific building materials (e.g. brick, porcelain). Swipes taken in some parts of the basement did show slightly elevated long-lived alpha radiation, but the values obtained were well below the 20 dpm/100 sq cm criterion (Table 4-1). RDC and radon concentrations were also within the normal acceptable range for residential structures.

[redacted] Street, Orange

Slightly elevated gamma exposure rates were found at a number of locations throughout this building. In most cases the exposure rates could be attributed to porcelain or structural brick. An area of concrete floor on the sixth floor of the building showed exposure rates up to 27 uR/hr. Four swipes were taken in this area, with long-lived alpha contamination found to be as great as 18.5 dpm/100 sq cm.

The sixth floor of this building should be investigated further to determine the actual nature and extent of contamination, especially as a large part of this floor was inaccessible on the day of the screening.

Air samples taken on the first floor of this building showed RDC and radon concentrations within normal indoor concentrations, but the number of samples collected and the ambient conditions at the time of their collection cannot be considered representative of the entire building.

[redacted] Street and [redacted] Street, Orange

The buildings at these addresses were screened for gamma exposure rates because of their possible association with operations at [redacted] Street. No evidence of elevated gamma radioactivity was found in either building; however, only a small part of [redacted] Street was accessible on the day of the screening.

3.4.3 SURVEYS REMAINING

Seven properties remain to be screened:

ıe

3.5 INTERIM REMEDIAL MEASURES

BRP requested businesses on the High and Alden Streets site to restrict working hours to a 40-hour week. BRP also recommended that each business retain an engineering firm to propose remedial measures. Two businesses, T&E Industries (Building F) and Zip Messenger Service (Building G), were

notified to limit exposure times in certain parts of their buildings to 25 hours per week, as an interim remedial measure.

Only T&E Industries implemented interim engineering remedial measures. These measures included the following:

- Applied epoxy sealants to concrete expansion joints, wall and floor joints, sewer openings, and cracks in the oven room area.
- Added an exhaust fan to the underground conduits that vent air from the sewers to the building's exterior.
- Added a second window fan in the oven room.
- Replaced wood floorboards with poured concrete.
- Changed the ventilation pattern during working hours.

Both T&E Industries and Zip Messenger Services limited the time workers spent in areas with the highest gamma exposure rates.

In July 1985, T&E Industries transferred its entire operation to a building several blocks away.

(DEC118/13)

4.0 RADIATION HAZARD ASSESSMENT

This section addresses the increased radiation doses and health impacts to the general public and residents of the U.S. Radium Corporation site and surrounding area. The slightly increased doses received by these individuals can, in a statistical sense, increase the incidence of health effects (excess fatal cancers) above those naturally expected for the individual and the general public. This section has been prepared by CDM with input by the USEPA Officer of Radiation programs. The hazard assessment is an evaluation of the potential routes of exposure to the contaminants at the sites.

4.1 BASIC FACTS ABOUT RADIATION AND ITS MEASUREMENT

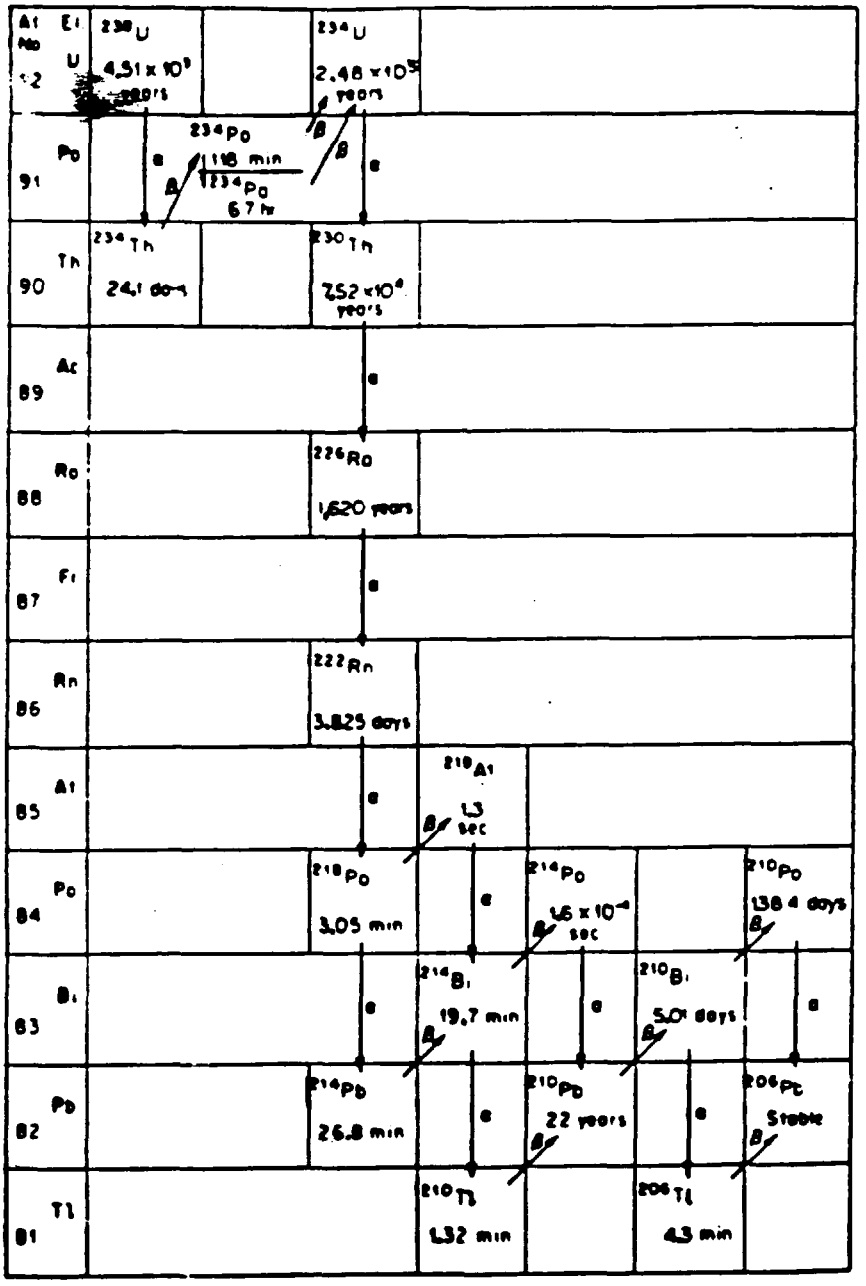
Atoms that spontaneously transform, or decay, into new atoms are termed radioactive. The decaying atom is called the parent, and the atom produced by the transformation is called the progeny. The rate at which atoms decay is the radioactivity, measured by the unit curie (Ci). A more convenient unit for measuring environmental radioactivity is the picocurie (pCi), which is one-millionth of one-millionth ($1x10^{-12}$) of a curie. The half-life of a radioactive substance is the time required for it to lose 50 percent of its radioactivity by decay. Each radionuclide has a unique half-life.

When atoms undergo radioactive decay, they emit radiation. The most common types of radiation are alpha particles, beta particles, and gamma rays. Radiation deposits energy in matter it travels through. Alpha radiation penetrates only a few millimeters into matter and beta radiation penetrates a few centimeters, unlike gamma radiation which can travel deeper into matter in the same way as X-rays. Alpha radiation will not penetrate through a layer of skin, whereas gamma radiation can easily penetrate tissue and hence deliver a dose to any internal organ. The amount of

radiation to which an individual is exposed may be expressed in terms of the amount of energy imparted to cells and tissue by the radiation and the degree of biological damage associated with the energy as it is absorbed. This absorbed energy is termed the absorbed dose and is given in units of rads, where 1 rad equals 100 ergs of energy absorbed per gram of material irradiated. When the irradiated material is living tissue, the damage per rad varies depending on the type of radiation. By applying the "quality factor" to each specific type of radiation, the degree of biological damage can be expressed independently of the type of radiation causing it. The biologically relevant absorbed energy is termed the "dose equivalent" and the unit is termed "rem." One rad is equal to one rem for less damaging radiations where the quality factor equals one (e.g., gamma rays). For comparison, 1 rad of internal alpha-deposited energy equals 20 rem because alpha particles are more damaging to tissue and the quality factor for alpha radiation is 20. The millirem equals one-thousandth ($1x10^{-3}$) of a rem and is the more common unit used to express doses from environmental levels of radiation.

When a succession of radioactive parent atoms decays to radioactive progeny atoms, a radioactive decay series is formed. Uranium-238 (U-238) is such a radioactive parent atom; the U-238 decay series is shown in Figure 4-1. The U-238 decay series includes thorium-230 (Th-230), radium-226 (Ra-226), radon-222 (radon or Rn-222), short-lived radon progeny, and other long-lived radioactive atoms. The U-238 decay series ends with lead-206 (Pb-206), an atom that is stable and not radioactive. When the progeny in a radioactive decay chain have shorter half-lives than the parent, the progeny radioactivities will increase until they equal the radioactivity of the parent. The increase in progeny radioactivities is termed in-growth.

Radon and radium are the radionuclides of primary importance at the U.S. Radium Corporation site. The half-life of radon (3.8 days) is short relative to the half-life of Ra-226 (1,620 years). As Ra-226 decays, the newly produced radon will begin to decay, and the radon radioactivity will become equal to the Ra-226 activity within 30 days, in an enclosed structure. Similarly, the short-lived radon progeny radioactivities will



Source: Sawyer, C.N. and McCarty, P.L.

FUNDAMENTALS OF CHEMISTRY FOR ENVIRONMENTAL ENGINEERS
McGraw-Hill, N.Y. 1978.

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Figure 4-1
U.S. Radium Corporation Site
URANIUM-238 DECAY SERIES

in-grow within four hours to equal the radioactivity of radon and Ra-226. When the radioactivities of the parent and its progeny are equal, the progeny are said to be in 100 percent equilibrium or simply "in equilibrium." If the progeny are diluted or carried away in the air as they are formed, they will not reach 100 percent equilibrium.

The only member of the U-238 decay series that is not a solid is radon. Radon is an inert gas and does not usually react chemically with other elements; it therefore can diffuse out of matter and into the atmosphere. The atmospheric radon concentration is measured in units of picocuries per liter (pCi/l). Once in the atmosphere, radon is transported downwind and decays into the short-lived radon progeny, which can attach to particulates in the air. Since radon is an inert gas, it is inhaled and exhaled, contributing very little radiation exposure to the lung. However, inhaled radon progeny can deposit on the surface of airways and in the lung and decay, transmitting alpha energy to surrounding tissues. Most deposition is due to radon progeny attached to suspended particles, but unattached progeny can also be deposited. Because of their short half-lives, progeny will decay before being removed from the lung.

The long half-life of radium, coupled with the chemical similarity of radium and calcium, provides the basis for it to be taken up and retained by calcium-rich organs. Once ingested or inhaled, radium (called a "bone seeker") will concentrate in bones or be secreted in milk as occurs with calcium. After deposition within bones, radium can decay and transmit alpha energy to them. Thus, even a very small quantity can produce harmful effects if deposited internally.

Trace amounts of U-238 and its progeny are found everywhere on earth; therefore, radon and its short-lived progeny contribute significantly to the natural background radiation exposure of the general public. Human exposure to radiation originates from cosmic and terrestiral external sources from naturally occurring radionuclides that are deposited inside

the body via the ingestion and inhalation pathways. Exposure to man-made sources results primarily from medical exposures (e.g., diagnostic X-rays), with minor contributions from sources such as airline travel, atmospheric weapons tests, the nuclear industry, consumer products, and technologically enhanced natural radiation.

4.2 EXPOSURE PATHWAYS AND EVALUATION OF HEALTH EFFECTS

Radiation and its associated health effects have been studied more thoroughly than health effects from other carcinogenic agents. The evaluation of health effects caused by low-level radiation is, however, difficult, and many uncertainties are associated with the estimation of risks from radiation. The traditional approach for estimating risks from low-level radiation exposure is to extrapolate from effects observed at high-radiation exposures.

There are five principal pathways by which individuals could be exposed from the existing conditions at the U.S. Radium site:

1. Inhalation of radon and radon decay products,

2. Direct exposure to gamma radiation,

3. Inhalation and ingestion of Uranium and Radium particulates,

4. Ingestion of ground or surface waters contaminated with radioactive materials,

5. Ingestion of foods produced in areas contaminated with radioactive materials.

For the discussion of health effects, only those pathways that would result in the largest radiological doses to the general public and residents have been considered in detail. These are inhalation of radon and radon progeny, direct exposure to gamma radiation, and inhalation or ingestion of

radioactive particulates. Based on estimates of radionuclide ingestion at the Montclair, West Orange and Oak Ridge radium sites, the health effects resulting from the two remaining pathways can be assumed to be insignificant for the U.S. Radium Corporation site compared to the effects of the other pathways.

4.2.1 INHALATION OF RADON AND RADON PROGENY

Radon, a naturally-occurring radioactive gas, is generally recognized as a key pollutant in the indoor environment. Radon is produced from the radioactive decay of radium-226, which occurs naturally in almost all soils and rocks. The radioactive decay of radon (radon progeny production) produces several alpha particle emitting radionuclides. Inhalation of these radionuclides exposes lung epithelial cells to (high linear energy transfer) alpha radiations, which are easily absorbed. High linear energy transfer radiations have a larger biological effect per unit dose than do low linear energy transfer radiations because they deposit more energy, and therefore, cause more damage per unit distance traveled. The relative biological effectiveness of alpha radiation is often many times greater than that of gamma radiations.

While the concentration of radon in the outdoor environment does not usually pose a significant health hazard, indoor concentrations can be several thousand times higher than outdoors. The rate at which radon enters a structure and the air exchange rate influence the radon concentration inside the structure. Radon concentrates in indoor environments because of the limited exchange between indoor and outdoor air. In many buildings, the most significant pathway of radon entry is migration from soil into the structure through the basement or foundation. The rate of radon entry is affected by many factors, including radium content of the soil near a structure, soil moisture and porosity, and structure type. The variability of all these factors, especially radium content, contributes to the wide distribution of radon concentrations that have been observed.

The hazards posed by radon arise primarily from two of its short-lived radioactive decay products, polonium-218 and polonium-214. These decay products (progeny) adhere to dust particles or other surfaces. If inhaled, the radioactive products deposit in the lungs, where they expose the surrounding tissue to alpha radiation. Such radiation exposure can lead to lung cancer.

The criteria developed for use at these sites are based on standards applicable to the clean-up of properties contaminated with radium-bearing uranium mill tailings and guidance for indoor radiation exposure due to radium-226 in Florida phosphate lands.

The standards developed under authority assigned to EPA by the Uranium Mill Tailings Radiation Control Act (40 CFR 192.12, 1983) stipulate that the concentration of radium-226 averaged over a 100 square meter area shall not exceed 5 pCi/g above background levels in the first 15 cm of soil beneath the surface and the average levels in 15 cm intervals below that shall not be more than 15 pCi/g above background levels. Also, in any occupied or habitable building, the level of gamma radiation shall not exceed the background level by more than 20 microR/hr.

The guidance developed by EPA for the Indoor Radiation Exposure Due to Radium-226 in Florida Phosphate Lands (FR, Vol. 44, July 2, 1979) stipulates that remedial action should be taken in all residences in which the initial annual indoor air concentrations of radon decay products exceeds 0.02 working level (WL)[1], including normal indoor background.

In addition, EPA has determined that in any occupied or habitable building, the concentration of radon decay products (including background levels) should not exceed an annual average radon decay product concentration of 0.02 WL and should in no case exceed 0.03 WL. The standard permits achieving 0.03 WL by removal of contaminated material and achieving a further reduction of 0.01 WL through active means when this is the only practical route (40 CFR 192.12).

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[1] A WL is any combination of short-lived radon progeny in one liter of air that will result in the emission of 1.3×10^5 MEV potential alpha energy.

Estimates of the risk associated with exposure to radon decay products are based on several studies of underground miners who were exposed to high levels of radon. A very high incidence of lung cancer has been well-documented in studies conducted in a number of countries. Cumulative exposure to the decay products is measured in terms of working level months defined as occupational exposure of a miner to 1 WL for 173 hours (a working month) (30 CFR Part 57).

Differences in normal breathing rates between miners and members of the general public complicates the conversion of exposure levels to cumulative exposure for these two groups.

Full time exposure of an average individual to 1 WL results in an exposure equivalent to 27 WLM per year. In the case of a miner exposed only during working hours, 1 WL results in 12 WLM per year.

Currently, the Mine Safety and Health Administration (MSHA) of the Department of Labor (DOE) limits the maximum permissible concentration of radon progeny in mines to 1.0 WL and limits occupational exposure to 4.0 WLM, corresponding to Federal Radiation Protection Guides. These limits are currently under review.

Current estimates suggest that the risk of lung cancer is doubled by a cumulative exposure of 20-100 WLM. (The average national lung cancer risk is about 5 in 100.) Statistically significant, increased risk of lung cancer in miners is observed for exposures as low as 80 WLM. In homes across the United States, measured exposure rates range from 0.08 to greater than 200 WLM per year. Lifetime exposures at these rates lead to cumulative exposures ranging from about 1 WLM to over 10,000 WLM. Thus, at the higher levels, a person's lifetime risk of lung cancer could be increased to well over one chance in two.

Radon progeny concentrations are significantly elevated in some buildings on the High and Alden Streets site. Quantitative estimates of risk to

workers and residents in the various buildings of the U.S. Radium Corporation site and the general public in the surrounding areas cannot be made at this time. These estimates require specific population data and a more thorough characterization of the radon progeny concentration levels. It can, however, be qualitatively determined that the elevated levels can increase the potential for the excess health effects to the affected population.

4.2.2 DIRECT EXPOSURE TO GAMMA IRRADIATION

Gamma radiation is a form of electromagnetic radiation similar to X rays. It is a very highly penetrating radiation due to its low linear energy transfer. As with all ionizing radiation, gamma rays cause injury by breaking biological molecules into electrically charged fragments called ions and, thereby, producing chemical rearrangements that may lead to cellular damage. Due to the low linear energy transfer, gamma rays disperse their energy over a relatively long distance. The adverse biological reactions associated with gamma rays, as well as with other ionizing radiations, are carcinogenicity (cancer), mutagenicity (genetic changes) and teratogenicity (birth defects). Further information on the effects of exposure to gamma radiation can be found in the reports of the Committee on Biological Effects of Ionizing Radiation (BEIR III) (1980) and EPA (1984a).

Several dose response models are used to estimate the risk of fatal cancer, serious genetic effects, and other detrimental health effects resulting from exposure to ionizing radiation. However, estimating radiation risks is not a mature science and risk assessments will change as additional information becomes available. EPA believes that risk estimated for the purpose of assessing radiation impacts on public health should be based on scientifically credible risk models that are unlikely to understate the risk. For estimating the risk associated with exposure to low LET (gamma) radiation, the EPA uses the BEIR-3 linear dose response models and an age averaged risk of 280 deaths per million person rems (EPA 1984a).

Quantitative risk estimates to the exposed population require that the distribution of population density for the affected area be known and

routes of exposure characterized. Aerial gamma radiation exposure surveys and field surveys show significantly elevated gamma levels on the entire former processing site. These gamma exposures can statistically increase the potential for excess health effects to individuals living or working in the vicinity of the site.

4.2.3 EXPOSURE TO RADIOACTIVE PARTICULATES

The inhalation, ingestion, or absorption of radioactive particulates can be expected to provide a pathway for radiation exposure at the U.S. Radium Corporation site. Contaminated particles originating in the soils where processing waste material or tailings were buried may become airborne under certain conditions. In addition, particulates contaminated with the long-lived alpha-emitters have been identified in some locations. These alpha-emitters may be residues of radium compounds handled at the site.

4.3 EXPOSURE ASSESSMENT

Residents of the U.S. Radium Corporation site are subjected to health risks primarily due to exposure by the following routes:

a. Inhalation of radon and radon progeny,

b. Direct exposure to gamma radiation from elevated indoor and outdoor contamination levels,

c. Inhalation and ingestion of radioactive particulates.

Inhalation of radon-222 and radon progeny is almost certainly the most important, since it greatly increases the risk of fatal lung cancer. Gamma emissions from the contaminated soil will expose all body tissues to ionizing radiation. Finally, uranium-234 and -238, thorium-230 and -232, and radium-226 ingested in garden vegetables or on soil consumed inadvertently, if absorbed, will deposit preferentially in bone, and they and their progeny will deposit in other tissues increasing the radiation exposure in those tissues. In addition, if not already present in the soil, concen-

trations of long half-life progeny of radon, specifically lead-210 and polonium-210, will increase as the radium-226 decays through radon and short half-life progeny. Both lead-210 and polonium-210 can be ingested from vegetables or soil. Inhalation of airborne radioactive soil particles or soil particles will only be a problem when the ground is disturbed and is not considered a significant route of exposure at this time.

4.3.1 INHALATION OF RADON AND RADON PROGENY

In order to determine the excess risk of lung cancer associated with exposure to radon progeny in the houses in the study area, the following assumptions were made: the population is composed of expected ratios of males and females, people spend 75% of their time at home and indoors, an average lifespan is 70 years, lung cancer has a 10-year latency and a lifetime plateau, and risk associated with radon exposure has a relative risk coefficient ranging from 1.0% per WLM to 4.0% per WLM (EPA 1986).

This relative risk coefficient is expressed as the percentage increase in the lung cancer mortality rate per unit dose. Table 4-1 shows the risk of lung cancer associated with lifetime exposure to different levels of radon progeny. The assumptions of 75% indoor occupancy, 70-year lifetime, and a 10-year latency with a lifetime plateau for lung tumors are based on figures reported by EPA (EPA 1984a). The assumption that a lifetime exposure to radon progeny increases the lung cancer mortality rate by an additional 1.0% to 4.0% of the normal rate is based on review of the literature and the general agreement of these figures with the risk estimates of other researchers (EPA 1986). The combination of these assumptions may overestimate the actual risk to individuals now in the area, and therefore, the risk estimates presented in Table 4-1 may provide an upper limit on current risks to the population. It should also be noted that the risks are for lifetime exposure and that living in the contaminated area for less than a full lifetime will decrease the risk proportionately.

4.3.2 EXPOSURE TO GAMMA RADIATION

Risk associated with various lifetime exposures from 100 mrem/year (slightly above background) to 1,000 mrem/year are presented in Table 4-2. These values are based on the BEIR III (1980) risk coefficients and on the assumptions of linearity at low dose levels (EPA 1984a). Also included is an assessment of the risk of cancer associated with exposure to the EPA-established indoor limit of 20 microR/hr approximately 170 mrem/year above background levels.

4.3.3 EXPOSURE TO RADIOACTIVE PARTICULATES

Presently, the moist conditions and vegetative cover of the soil inhibit the potential for the spread of airborne contaminants from the former radium-processing facility. Inside the buildings at this site, however, preliminary measurements have determined that surface contamination is present in some locations. Under certain conditions, this contamination could become airborne and be inhaled by workers and residents. Inhalation of this contaminated dust would provide a pathway for radium to enter the body, increasing the risk to the exposed individuals.

(DEC135/16)

TABLE 4-1

ESTIMATED EXCESS RISK[a] OF LUNG CANCER ASSOCIATED WITH LIFETIME INDOOR EXPOSURE TO RADON-222 AND ITS PROGENY

Concentrations (WL)	Relative Risk Coefficient	
	4.0%	1.0%
greater than 0.5	greater than 4.70×10^{-1}	greater than 1.98×10^{-1}
0.1-0.5	1.66×10^{-1} to 4.70×10^{-1}	4.73×10^{-2} to 1.98×10^{-1}
0.02-.1	3.88×10^{-2} to 1.66×10^{-1}	9.84×10^{-3} to 4.73×10^{-2}
less than 0.02	less than 3.88×10^{-2}	less than 9.84×10^{-3}

[a]Calculation based on the assumption that exposure to 1 WLM produces a relative risk for developing lung cancer of 1.0% to 4.0%, 75% occupancy of the nosue (EPA 1986).

TABLE 4-2

ESTIMATED EXCESS RISK OF FATAL CANCER ASSOCIATED WITH VARIOUS LIFETIME DOSES OF GAMMA RADIATION

Dose (mrem/year)	Lifetime Risk[a]
1,000	1.98×10^{-2}
900	1.78×10^{-2}
800	1.58×10^{-2}
700	1.39×10^{-2}
600	1.19×10^{-2}
500	9.90×10^{-3}
400	7.92×10^{-3}
300	5.94×10^{-3}
200	3.96×10^{-3}
100	1.98×10^{-3}
175[b]	3.46×10^{-3}

[a]Based on data from BEIR III (1980) and assuming linearity at low doses (EPA 1984a). It should be noted that work in progress to convert to relative risk models as recommended by EPA's Science Advisory Board would yield a lifetime risk of 2.79×10^{-2} for a dose of 1,000 mrem/yr. All risk estimates under this model will be 41% greater than those listed in Table 4-2.

[b]Risk at EPA regulated level of 20 uR/hr above background levels.

4.4 REFERENCES

EPA 1984a — U.S. Environmental Protection Agency (USEPA), 1984. Radionuclides Background Information Document for Final Rules, Volume 1. U.S. EPA, Office of Radiation Programs. Washington, D.C., October 1984, EPA 520/1-84-022-1.

EPA 1986 — U.S. Environmental Protection Agency (USEPA), 1986. Background Information Document - Final Rule for Radon-222 Emissions from Licensed Uranium Mill Tailings. U.S. EPA, Office of Radiation Programs, Washington, D.C., August 1986, EPA 520/1-86-009.

(DEC135/16)

5.0 DATA REQUIREMENTS

The former radium-processing facility at High and Alden Streets and some adjacent properties have been investigated by NJDEP and EPA contractors. The resulting data are adequate to characterize the types and degree of hazards present on site and to estimate exposures to the population working or living in the immediate vicinity of the site, based on existing conditions. However, better definition of site conditions is needed to develop and evaluate remedial alternatives. Therefore, additional data will be required.

The data collected will be used to develop a conceptual model of the contamination at the High and Alden Streets site and vicinity properties, including a detailed definition of its extent and an evaluation of its potential to migrate off site. The investigation must address not only remediation of air, soil, and water, but also the remediation or demolition of contaminated buildings.

NJDEP and EPA contractors have also investigated a number of properties with suspected or demonstrated associations with activities of U.S. Radium Corporation. Many of these properties show evidence of radium contamination and will require further investigation to define the extent of contamination indoors and outdoors. Again, remediation of the buildings must be addressed. Documentary evidence may be required to confirm that the radium-handling activities that took place were performed for U.S. Radium Corporation.

The following sections describe the data gaps that have been identified.

5.1 HIGH AND ALDEN STREETS SITE

Investigations by BRP, D&M, and EPA demonstrate the presence of elevated levels of radiological contamination throughout the High and Alden Streets site. The RI at this location must focus on defining the extent and nature of the contamination in sufficient detail to assemble and evaluate remedial alternatives.

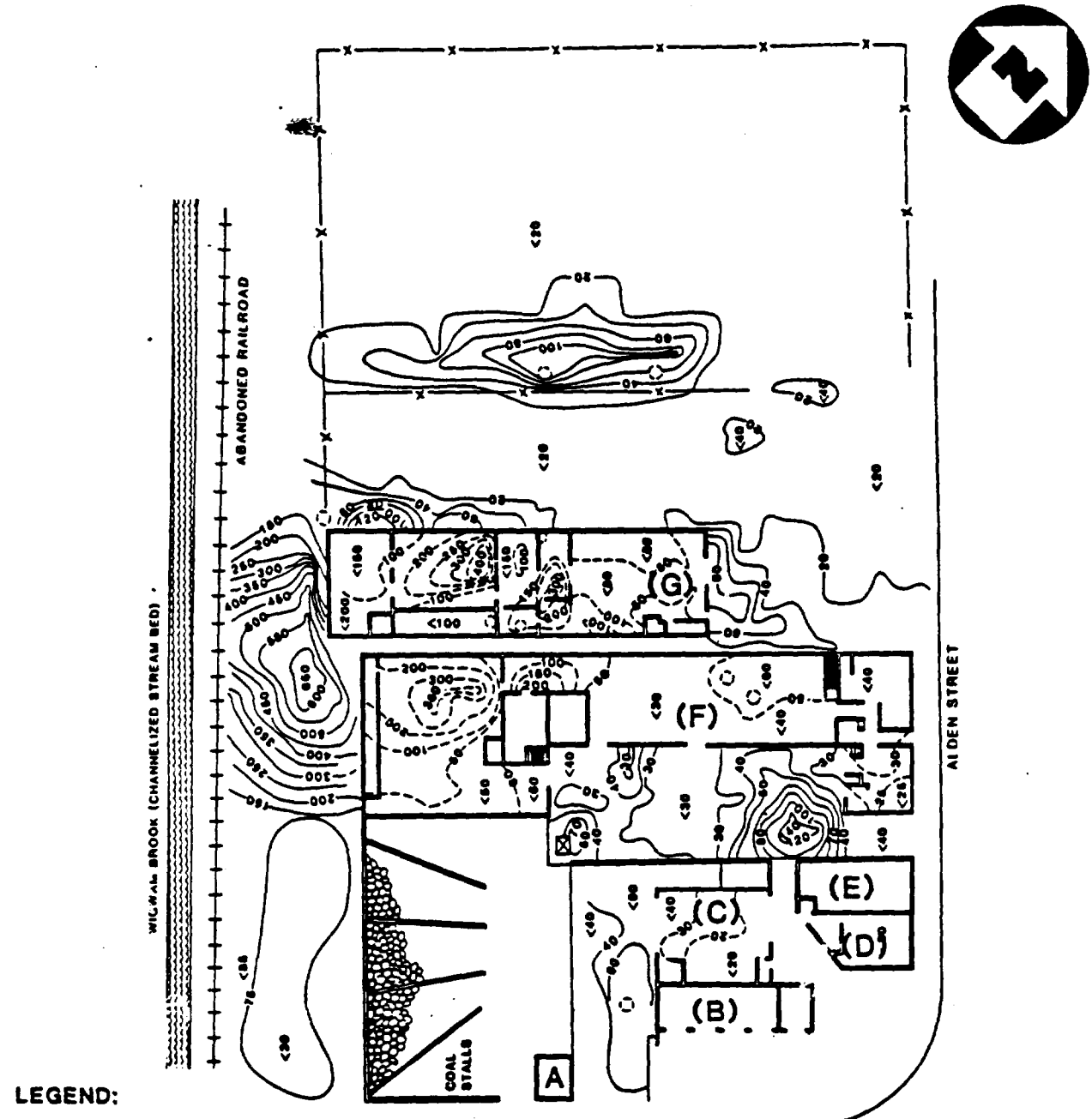
Radon or RDC has been monitored at all buildings on site except Building E. Monitoring results are supported by results of instantaneous or short-term air sampling performed at later dates. Further monitoring of indoor radon or RDC for environmental purposes is unnecessary.

The extent of elevated gamma exposure rates at the High and Alden Streets site has been partially defined by BRP. Additional work will be required to complete the survey and locate both indoor and outdoor measurements on a reproducible grid. BRP took waist-high scintillometer readings at the intersections of a 20-foot grid outdoors and a 10-foot grid inside buildings. The gamma isoexposure map (Figure 5-1) shows the interpolated results of this survey. The original grid-point measurements should be obtained, if available. If they are unavailable, or if the locations of the measurements cannot be tied into the existing coordinate system, the entire property will be resurveyed. If the BRP field data are satisfactory, a number of scintillometer measurements will be made to compare the BRP calibration to that used during the RI.

In some areas, such as the two lots on the west end of the site, only an upper limit for the range of results is presented. If BRP field results cannot be used, additional surveys must be performed to determine actual exposure rates in this area.

No gamma exposure survey data have been reported for the interiors of Buildings A, B, D, or E or the property around these buildings. Gridded gamma exposure surveys must be performed throughout these areas. Readings should be taken at ground level to properly define the extent of contamination.

The extent of borings performed to date at the High and Alden Streets site is not sufficient to define the extent of subsurface contamination across the site. Much of the contaminated area has not yet been investigated and several borings in contaminated areas were not deep enough to determine the maximum depth of contamination. All holes should be drilled past the limit of measureable contamination. Results from investigations at other radium



LEGEND:

--- ISOEXPOSURE LINES INSIDE BUILDINGS

—— ISOEXPOSURE LINES OUTSIDE BUILDINGS

◌ ISOLATED HIGH READINGS

20 = GAMMA ISOEXPOSURE RATE IN MICROROENTGEN PER HOUR (μR/hr) AT 1 METER ABOVE GROUND

SOURCE: NUS, 1984

NOT TO SCALE

CDM

environmental engineers, scientists, planners & management consultants

FIGURE 5-1

U.S. Radium Corporation Site
GAMMA RADIATION ISOEXPOSURE MAP
HIGH AND ALDEN STREET SITE

sites suggest that downhole gamma logging is adequate to define the extent of contamination, when supported by radiochemical analysis of soil samples. At this time, an estimated 100 borings located on a grid system will be required to characterize the High and Alden Streets site. At least 10 per cent of these should be split-spoon sampled.

Soil samples collected on site must be analyzed. The first purpose of these analyses is to estimate the quantity of radioactive isotopes on site. The second purpose is to characterize the contaminated soil materials in order to evaluate treatment alternatives, model impacts of remedial alternatives, and compare them with contaminated materials found off site. Some recommended analyses are mineral and bulk density of materials, sieve size analysis, moisture content, organic content, and de-emanation fraction.

Gamma surveys have clearly demonstrated that contamination extends as far as Wigwam Brook. The BRP investigation of some adjacent properties suggests that contamination may not extend across the brook, but the surveys are incomplete. Previous field investigations have not included any subsurface measurements or sampling along Wigwam Brook. These data should be obtained.

Wigwam Brook is channelized with a concrete bottom and embankments. Sanford real estate and tax maps from 1911 to 1932 show Wigwam Brook as a straight channel along the High and Alden Streets property, but New Jersey Geological Survey topographic maps from the same period show it meandering over its entire course. The present channel was built in the late 1930s. The brook is likely to have been contaminated by runoff from ore and tailings piles on the U.S. Radium Corporation property and may have been a disposal place for radium-processing wastes.

Downhole gamma logging and split-spoon sampling will be required on both sides of the brook. At a minimum, these borings must extend below the current channel of the brook and must extend past any detectable contamination. Because the brook's course during the period of radium-processing

activities is uncertain, borings should be distributed to cover the area possibly affected. The boring program should include locations upstream of the former processing facility and should continue as far downstream as contamination can be detected. If practical, soil samples should be collected from beneath the channel bottom, particularly near areas where ore or tailings are believed to have been stored, and core samples taken from the concrete channel.

In addition to Wigwam Brook, sediment samples are needed from other locations around the former processing facility where storm water runoff from the site could have deposited contaminated sediments. Offsite sampling also will be required to establish background radiological levels.

Ground water movement or quality at the High and Alden Streets site has not been studied. A comprehensive ground water monitoring program will be needed to establish a hydrological profile of the area and to determine if local ground water has been adversely affected by contamination at the former radium-processing plant. The long-term study should include installing several pairs of shallow and deep monitoring wells to tap unconsolidated material and bedrock aquifers, respectively.

The outdoor air quality measurements performed during the BRP study at the site indicate that an extensive air monitoring program is not necessary for the RI. Air monitoring will be required, however, to provide health and safety data during certain outdoor phases of the RI, such as drilling and split-spoon sampling, and during remedial activities. The health and safety air monitoring program should include sampling for radon gas, radon progeny, total suspended particulates, and respirable dust.

In addition to removing contaminated soils and controlling migration of radionuclides, it may be necessary to consider decontamination or demolition and removal of portions of some or all of the buildings on site. In order to evaluate this alternative, a detailed radiological survey will be needed to identify the contaminated areas of each structure. The investigation must include sampling of building materials in areas of elevated

radiation to define the nature of the contamination. Another requirement of the remedial evaluation is a site inventory to determine b··· ding dimensions, the types of structural materials, and site features that might affect remediation. Some pilot testing may be needed if treatment alternatives such as incineration are considered.

5.2 VICINITY PROPERTIES

Approximately 140 vicinity properties have been identified adjacent to or in the immediate vicinity of the former radium-processing facility (High and Alden Streets site). These properties are encompassed in an area of elevated gamma radiation exposures identified from the results of the aerial survey of Orange, Montclair, and Glen Ridge, New Jersey, performed in May 1981. The elevated levels of gamma radiation detected by the survey suggest that some or all of these properties may be contaminated with radium. The extent of contamination at the vicinity properties has not been characterized or defined completely. To date, the only onsite radiological investigation of the vicinity properties was that conducted by NJDEP and BRP in January 1984 at properties adjacent to the processing site.

The BRP investigation had originally identified 51 properties to be studied; however, site access could not be obtained for 20 properties. Of the 31 properties surveyed, 2 showed elevated indoor gamma exposure rates and 6 had elevated outdoor gamma exposure levels. None of the investigated properties had radon concentrations above background. No studies have been conducted at any of the other vicinity properties.

Although the BRP survey identified elevated radiation levels at some vicinity properties, the investigation was limited in scope and did not provide data for all the properties. Extensive investigative surveys will be needed to provide adequate information about the extent of contamination on the vicinity properties.

In order to generate those data necessary to assemble and evaluate remedial alternatives for contaminated properties in the vicinity of the High and Alden Streets site, the Remedial Investigation of the vicinity properties should include radon and RDC measurements, indoor and outdoor gamma surveys, and sampling and analysis of surface and subsurface soils.

Radon and RDC have not been measured at most of the vicinity properties. Radon or RDC concentrations significantly greater than background may indicate the presence of radium contamination near or within the building. Grab samples should be taken in each building on the vicinity properties to provide these data, as well as health and safety information for the field investigators.

The results of the aerial and BRP surveys indicate that elevated gamma exposure rates exist in the vicinity of the High and Alden Streets site, and they identify the former radium-processing site as the primary radiation source. However, the high levels of gamma radiation produced by contamination at that site can mask less intense radiation produced by other sources in the vicinity when surveyed from the air. Therefore, gamma radiation measurements must be taken at each vicinity property in order to further define contamination indicated by the previous surveys. Surface-level outdoor and indoor gamma surveys will be needed to locate the radiation sources, and outdoor subsurface gamma logging may be necessary to establish the depth of contamination.

Data available from previous surveys are not sufficient to identify the source(s) of the gamma radiation. Sampling and analysis of vicinity property soil will be needed to identify the isotopes producing radiation. Split-spoon soil samples taken from some of the gamma log boreholes will also be needed to determine the contamination depth. Soil samples should be obtained in areas of elevated radiation levels and analyzed for radioisotopes. Other chemical and mineralogical analyses may be necessary to confirm that materials found off the processing site are the same type as those found at the site.

Each contaminated property identified during the RI will be surveyed to determine the physical features and dimensions of the property. Detailed plans that show the location and nature of these features will then be prepared. This information will be needed for cost and design evaluations of remedial alternatives.

5.3 SATELLITE PROPERTIES

The 20 satellite properties have been identified from U.S. Radium Corporation records and by radiological surveys of neighborhoods identified by a 1981 gamma survey overflight of the area surrounding the High and Alden Streets site. The only onsite radiological investigation of the satellite properties was that conducted by BRP. The extent of that study was limited; it included only nine properties.

Indoor radon progeny were sampled at only one satellite property (41/49 South Day Street). Elevated indoor radon or RDC may indicate radium contamination in or near the building; therefore, grab samples should be taken in each building on the satellite properties. These data are also needed to evaluate the properties from a health and safety perspective.

The aerial and BRP surveys have identified elevated gamma exposure rates on some satellite properties. However, the data generated do not sufficiently establish the nature and extent of the radiation. Outdoor and indoor gamma measurements are needed at each property to locate the sources of radiation. Outdoor subsurface gamma logging will be needed at each property to determine the depth of contamination.

The sources of radiation at the satellite properties were not identified by the previous investigations. Soil samples must be taken in the areas of elevated radiation and analyzed for radioisotopes. Additional chemical or physical analyses may be required to associate the materials found at the satellite properties with those found at the High and Alden Streets site. Gamma log boreholes should be split-spoon sampled and analyzed to establish the depth of contamination.

No sampling has been conducted in any of the satellite property buildings for residues of radioactive materials. Alpha swipes and samples of building materials should be taken from indoor surfaces that have elevated levels of radiation. This will locate and identify the radioactive isotopes inside the buildings.

Additional satellite properties may be identified during the RI. In some cases, it may be necessary to extend the radiological survey of a particular satellite property past its boundaries to other surrounding properties. Additional surveying would be done if initial survey results indicate that contamination may extend to areas beyond the property limits. Another reason for expanding the satellite properties survey is suggested by the aerial survey. It appears that some areas of elevated radiation may be too large to be caused only by the satellite properties identified to date. This is evident from the oversized radiation areas surrounding the [redacted] Street properties and the [redacted] and [redacted] Street properties.

Each contaminated property identified during the RI will be surveyed to determine its physical features and dimensions. Detailed plans that show the location and nature of these features will then be prepared. This information will be needed for cost and design evaluations of remedial alternatives.

5.4 BACKGROUND MEASUREMENTS

Levels of local background radioactivity have been measured in previous studies for the U.S. Radium Corporation site and for other radium sites in the area. These measurements were sufficient to establish typical background values for surface gamma exposure rates and RDC, but did not adequately establish ranges for naturally occurring radionuclides in soil or water. It is important to establish these background values, as radionuclide concentrations that are below environmental or public health criteria may still be elevated enough above background to indicate more severe contamination nearby.

(DEC118/10)

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(DEC118/23)

APPENDIX A

U.S. RADIUM CORPORATION SITE
REPORT OF FIELD INVESTIGTIONS

December 10, 1985 through December 12, 1985

(RW17/80)

U.S. RADIUM CORPORATION SITE REPORT OF FIELD INVESTIGATIONS
DECEMBFR 10, 1985 through DECEMBER 12, 1985

1.0 INTRODUCTION

Field investigations were conducted at the former U.S. Radium Corporation radium processing site at High and Alden Streets from December 10 through December 12, 1985. Three of the existing seven buildings on the property were entered for the purpose of collecting radiological and other pertinent data, as described in the U.S. Radium Corporation Site Interim Project Operations Plan (IPOP). The buildings investigated during this period were Building F (T&E Industries, Inc.), Building G (Zip Parcel & Messenger Service), and Building A (Orange-Alden Fuel Company). The remaining four buildings were not entered due to lack of access permission, however, field investigations for those buildings have been scheduled for the near future.

Site history and summary of results from previous site investigations are provided in the IPOP, with references available for details.

2.0 FIELD SURVEY TEAM

A three member field crew was used on all three days of the survey, and consisted of William Smith (CDM), serving as the On-site Coordinator, Donna Wooding (WESTON), functioning as the Site Health Physicist and Site Safety Officer, and Dean Scari (CDM) for Instrument and Decontamination Assistance. Level C protection was worn by all team members at each building, as outlined in the IPOP Health and Safety Plan.

3.0 FIELD ACTIVITIES AND MEASUREMENTS

3.1 BUILDING F, T&E INDUSTRIES, INC.

Building F was entered on December 10, 1985 from the northeast entrance. The survey took place between 12:00 p.m. and 2:00 p.m.

3.1.1 RADON/RADON DAUGHTER CONCENTRATION (RN/RDC) MEASUREMENTS

Two Rn/RDC samples were collected in the oven room located on the lower level, western-most corner of the building. This location was selected for Rn/RDC measurements because previous radiological investigations reported this area as having the highest gamma exposure rate levels, although it appeared to not be closed off very well. It appeared that all rooms were subject to some air circulation.

3.1.2 GAMMA EXPOSURE RATE SURVEY

A gamma exposure rate survey was not conducted in Building F because gamma rates were found to exceed the capabilities of the survey instrument being used. Gamma exposures are therefore known to be greater than 500 micro-roentgen-per-hour (500 uR/hr).

3.1.3 SURFACE ALPHA CONTAMINATION

A surface alpha survey was conducted throughout approximately 75 percent of Building F, and was completed in two parts. First, using a portable ratemeter scaler and a zinc sulfide alpha scintillometer, a scan was made of representative wall, ledge, and other surfaces throughout both levels of Building F. Those areas which exhibited elevated total alpha levels were then sampled for removable alpha contamination, by taking a swipe covering approximately 100 square centimeters. Swipes were taken in ten locations in Building F; three on the lower level and seven on the upper level.

3.1.4 GENERAL OBSERVATIONS

Throughout the survey observations were made as to structure, general conditions, and contents of all rooms within the building. Notes were made of unusual equipment or supplies where applicable.

3.2 BUILDING G, ZIP PARCEL & MESSENGER SERVICE

The field survey was conducted at Building 1 December 11, 1985 from approximately 12:00 p.m. until 1:30 p.m.

The building owner remained on the premises during the investigation, and provided access to all parts of the building.

3.2.1 RADON/RADON DAUGHTER CONCENTRATION MEASUREMENTS

Two Rn/RDC measurements were taken in the Zip Parcel & Messenger Service Building. The first sample was collected in the back storage room. The owner of Zip reported that this room was being used to store furniture and supplies that had been left by the previous owner of the building. This room is small and appeared somewhat closed off from the remainder of the building. The second Rn/RDC sample was collected in the men's room located in the front portion of the building on the eastern side. This room was not particularly well closed off, however, it seemed to be less drafty than the large room with bay doors.

3.2.2 GAMMA EXPOSURE RATE SURVEY

The gamma exposure rate survey covered approximately 70 percent of the area of each room. Records were made of gamma exposure rates at 14 locations, particularly areas with anomalous readings.

3.2.3 SURFACE ALPHA CONTAMINATION

As described in the IPOP, a survey of total alpha contamination was performed in those areas exhibiting gamma anomalies or in areas, which by location or structure, were suspected of potential surface alpha contamination. Nine swipes were taken at those locations at which total alpha levels appeared elevated with respect to general levels within the building.

3.2.4 GENERAL OBSERVATION

Observations were noted in Building G as to locations of rooms, general appearance and apparent age of structure.

3.3 BUILDING A, ORANGE-ALDEN FUEL COMPANY

The field survey at Building A was conducted on December 12, 1985 from approximately 12:00 pm to 1:30 pm. An employee of the Orange-Alden Fuel Co. assisted the survey team by answering questions concerning history of the building. Regular business activities were continued during the investigation.

3.3.1 RADON/RADON DAUGHTER CONCENTRATION MEASUREMENTS

A single Rn/RDC sample was collected in the back room (north corner) of the Orange-Alden Fuel Co. The building is very small, and thus one sample was believed to be sufficiently representative of conditions throughout the building. The conditions within the building were less than satisfactory for obtaining Rn/RDC measurements because the door was frequently opened, which could be expected to affect the Rn/RDC levels.

3.3.2 GAMMA EXPOSURE RATE SURVEY

Building A was surveyed for gamma exposure rates, scanning approximately 85 percent of the building interior. In addition, the shed northwest of the building was scanned. Exposure rate measurements were recorded at 11 locations.

3.3.3 SURFACE ALPHA CONTAMINATION

Following a general scan for surface alpha contamination, eight swipe samples were collected. Since the scan did not result in any significantly elevated readings, swipe samples were taken at locations which were dusty or appeared old or original.

4.0 FIELD SURVEY RESULTS

4.1 BUILDING F, T & E ELECTRONICS

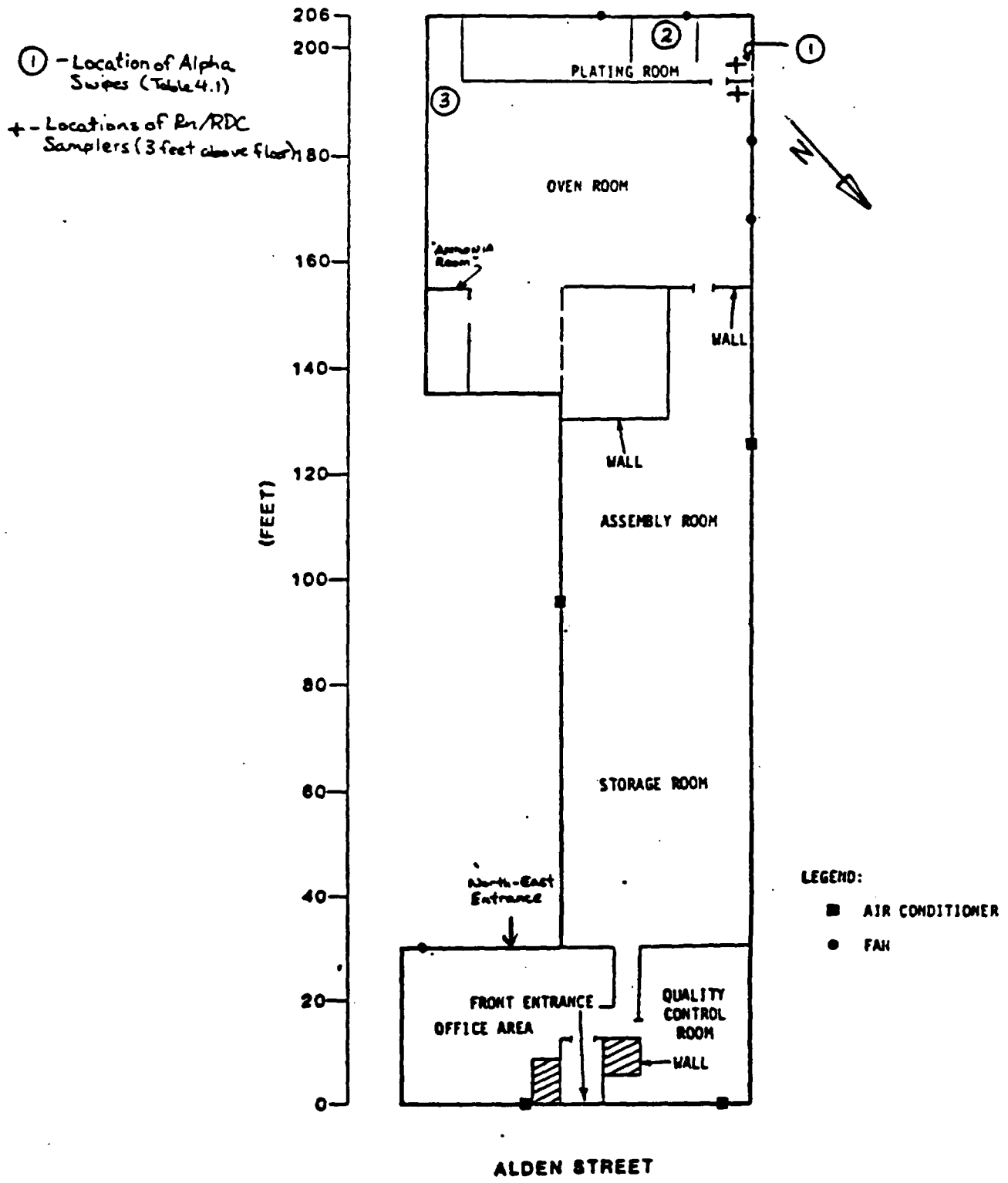
Figures 4.1 and 4.2 provide floor plans for the first and second levels of Building F, with sampling and measurement locations shown.

In general, the field team found Building F to be very dusty, and in a state of disrepair. The building had been closed since July 1985. The lower level had concrete floors with brick and cinderblock walls. A thick layer of dust covered all ledges, shelves, heaters, and remaining equipment throughout both levels. Many of the painted surfaces were peeling, exposing bare walls or a second layer of paint. On the lower level, signs were posted indicating that certain rooms had been used for activities involving toxic chemicals (ammonia). A large amount of corrosion was evident on metal surfaces in these rooms. Other than the signs and a few unidentified large machines, nothing remaining in Building F was useful in identifying previous activities. Photographs were taken of most sampling locations throughout both levels, and are available from CDM, Edison, NJ. A photograph (with the camera strobe) was taken of the large machine located on the first level identified with the letters T&E stenciled on the top.

Radon/radon daughter concentration measurements were measured to be higher than the concentrations measured by previous investigators (Eng, 1980; D&M, 1983). The radon concentrations were 98.4 $\pm$ 4.5 and 81.7 $\pm$ 4.5 pCi/l taken in the oven room (western corner), first level, Building F. Only one RDC measurement was analyzed, showing 0.29 WL in the oven room. The RDC/Rn equilibrium was calculated to be 35 percent.

Surface alpha measurements taken throughout both levels showed a generally homogeneous distribution of elevated total alpha. Total alpha measurement generally ranged between 1500 and 2000 dpm/100 sq. cm. Several locations on the upper level showed total alpha levels that were markedly higher than

FIGURE 4.1

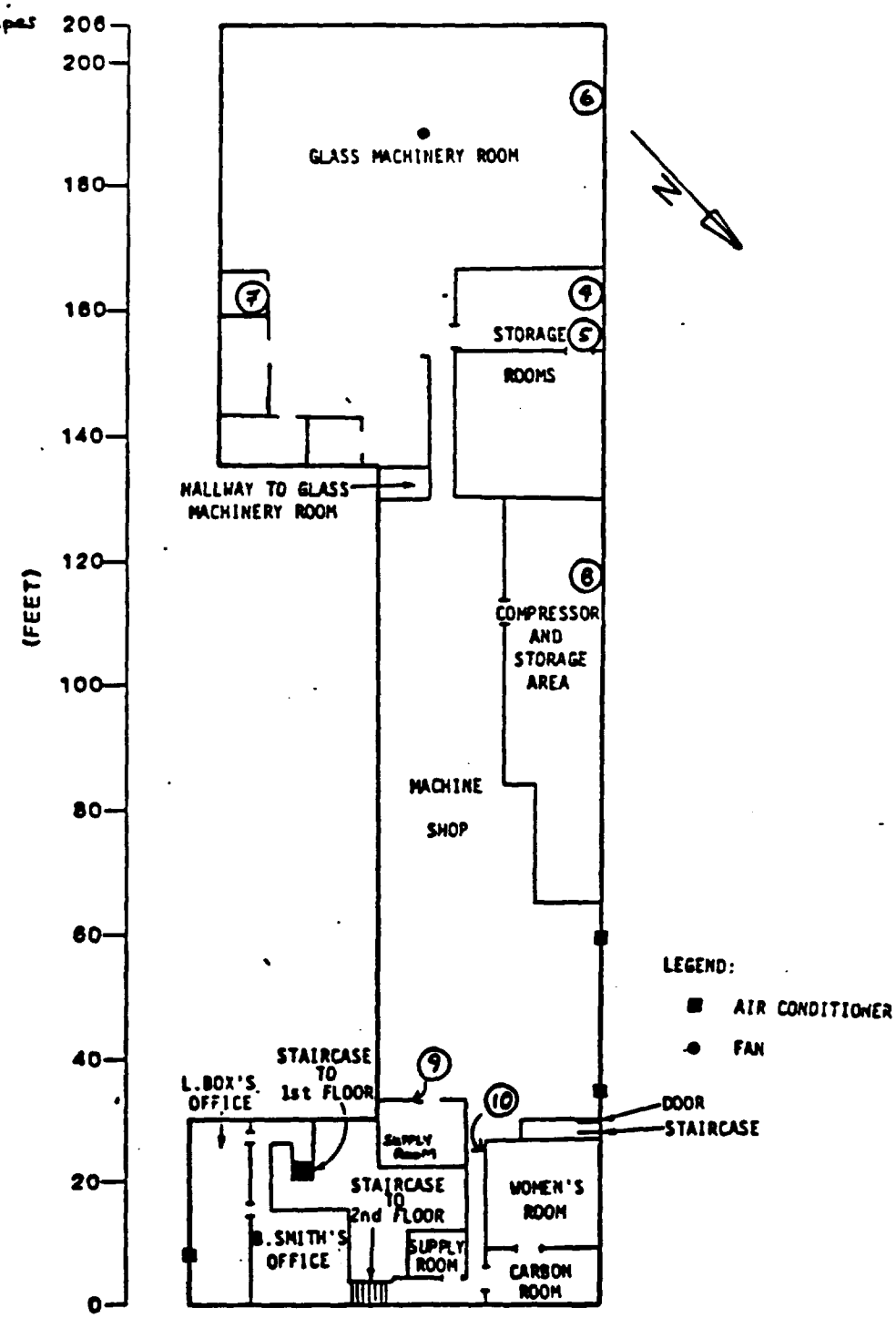


Base Map from Dames & Moore, 1983
Amended based on 12/10/85 Site Visit

BUILDING F (T & E INDUSTRIES, INC.)
(INCLUDING VENTILATION SYSTEM)
1st FLOOR
SHOWING SAMPLING AND MEASUREMENT LOCATIONS

FIGURE 4.2

(1) - Location of Alpha Swipes (Table 4.1)



Base Map: Dames & Moore, 1983
Amended based on 12/10/85 Site Visit

BUILDING F (T & E INDUSTRIES, INC.)
(INCLUDING VENTILATION SYSTEM)
2nd FLOOR
SHOWING SAMPLING AND MEASUREMENT LOCATIONS

the already elevated readings in the remainder of the building. Swipes taken at two locations (on top of the heater in the western corner,and on the bare wall where paint had chipped off) resulted in long-lived removable alpha levels of 21.3 and 348 dpm/100 sq. cm. respectively. Swipes taken at other locations in the building showed negligible long-lived alpha radiation. Results of the total and removable alpha survey are provided in Table 4.1.

4.2 BUILDING G, ZIP PARCEL AND MESSENGER SERVICE

Figure 4.3 provides floor plans for Building G, with sampling and measurement locations shown.

Building G was found to be dusty and in some state of disrepair. In some places bricks, which appear to be part of the original structure, were exposed along wall surfaces. Floor boards were warped and cracked in the two rear (SW) rooms, exposing foundation soil.

A white granular substance was observed beneath the wooden floor of the rearmost room. The substance showed no elevated radioactivity.

The front (NE) portion of the building is currently being used as a parcel delivery service, and has a large bay door. The owner of the building uses a small room in the front of the building as his office which he occupies approximately 20 hours per week.

The Rn/RDC measurement taken in the back storage room (lumber room), which was being used to store miscellaneous items left by the previous owner, resulted in 160 $\pm$ 7 pCi/l and 2.48 $\pm$ 0.004 WL. The sample collected in the men's room resulted in 52.8 $\pm$ 6.1 pCi/l and 0.50 $\pm$ 0.02 WL. The calculated RDC/Rn equilibrium is 155%.

Results of the gamma-ray exposure rate survey are provided in Table 4.2. Gamma exposure rates ranged from 25 uR/hr to 456 uR/hr measured at 1 meter above the ground. A gamma reading was also taken at the ground surface at the location with the highest count rate, resulting in a 646 uR/hr exposure rate.

TABLE 4.1

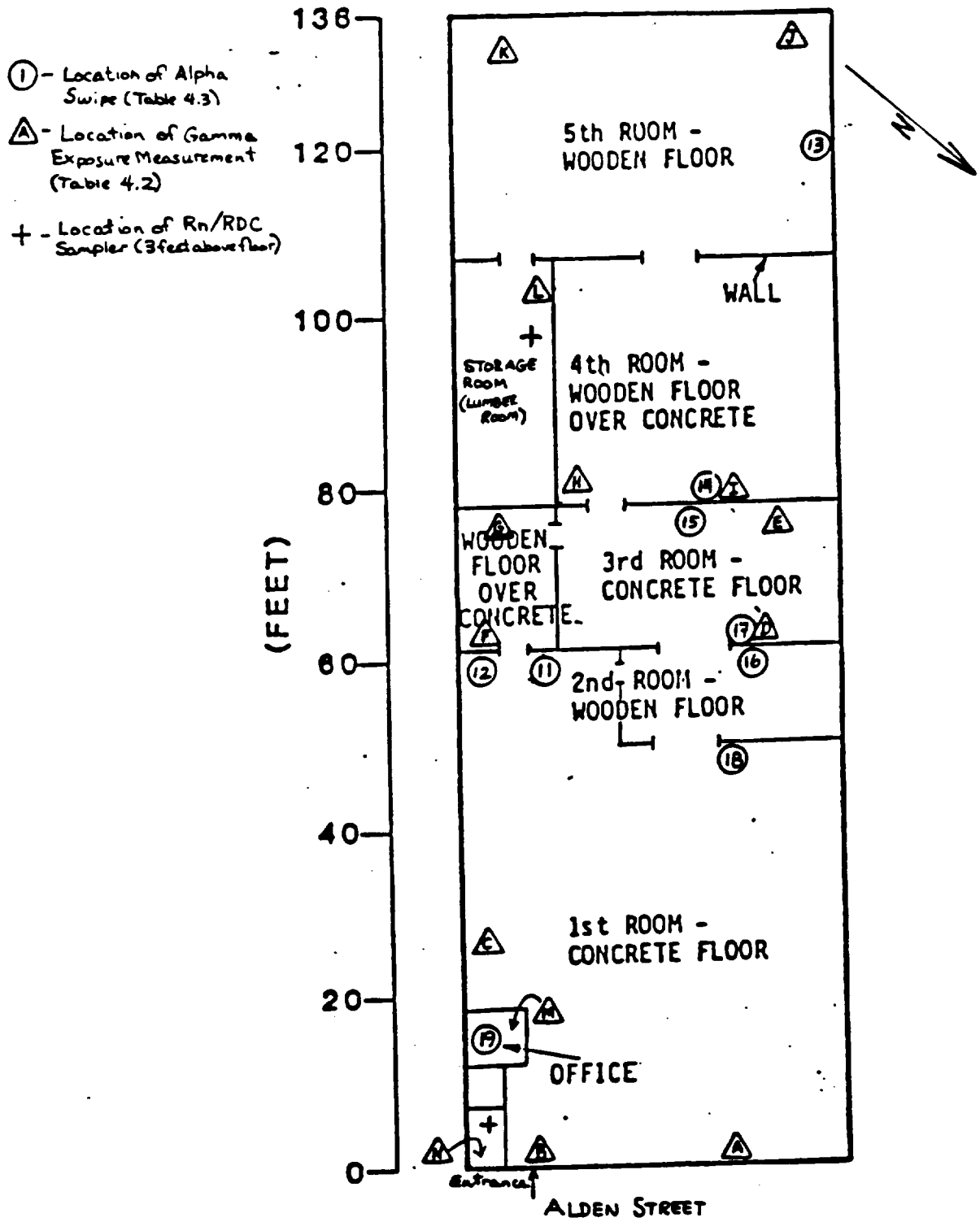
Building F (T&E) Alpha Contamination Survey Results

Location Sampled	Total Alpha Contamination (dpm/100 sq. cm)	Removable Alpha Contamination (dpm/100 sq. cm)
1. (LL)* window ledge	-	2.9
2. (LL) beam on floor	-	3.2
3. (LL) brick support	-	4.8
4. (UL)* top of heater	-	3.2
5. (UL) table top	-	4.2
6. (UL) heater in back	>4000	21.3
7. (UL) light switch	-	1.6
8. (UL) window ledge	>6300	1.9
9. (UL) door knob	>30,000	6.8
10. (UL) bare panel	>600,000	348.0

*LL (lower level), UL (upper level).
- No total alpha measurement taken at this location

(125/8)

FIGURE 4.3



Base Map: Dames & Moore, 1983
Map amended based on 12/11/85 site visit

FLOOR PLAN OF BUILDING G (ZIP MESSENGER) SHOWING SAMPLING AND MEASUREMENT LOCATIONS

TABLE 4.2

Building G (Zip) Gamma Exposure Rate Survey Results

Location of Measurement	Exposure Rate (uR/hr)
A. Garage Door	81
B. Front Door	65
C. East Wall Behind Office	72
D. Behind Second Wall (right side)	217
E. Before Third Wall (right side)	233
F. Behind Second Wall (left side)	341
G. Before Third Wall (left side)	413
H. Behind Third Wall (left side)	342
I. Behind Third Wall (right side) (1 meter/surface)	456/646
J. Back Wall (right)	114
K. Back Wall (left)	248
L. Lumber Room (right)	25
M. Office	57
N. Men's Room	50

(125/8)

Total alpha measurements were homogeneously elevated throughout building G, although some markedly elevated readings were observed. The general range was 2000 to 3 10 dpm/100 sq. cm. Alpha swipes revealed elevated removable alpha levels at all locations sampled. Measurements made on the swipes ranged from 7.9 to 933 dpm/100 sq. cm. (Table 4.3).

4.3 BUILDING A, ORANGE-ALDEN FUEL COMPANY

The interior of building A was generally in good condition. Wall surfaces were varnished wood and floors were either carpeted or tiled. This building is reported to have been continuously occupied by coal company offices since before 1911. No significant quantity of dust was evident on any surfaces inside Building A. A small safe exists in the back of Building A, housed in a wooden closet. This safe appeared very old, and may date to the period of U.S. Radium Corporation activities.

A small wooden shed attached to the back of building A contained miscellaneous lumber and tools. Located adjacent to the shed is a coal yard, with piles of varying grades of coal and a large truck scale. Figure 4.4 shows a floor plan of building A, reproduced from field observations. Sampling and measurement locations are also shown.

The results of the Rn/RDC sample collected in the back room of Building A were 4.46 $\pm$ 0.05 pCi/l and 0.019 $\pm$ 0.004 WL, respectively. Because of the substantial ventilation in Building A, the Rn and RDC levels measured may or may not be representative of the worst possible potential levels. The RDC/Rn percent equilibrium calculated for Building A is 43%.

Exposure rates measured in Building A are provided in Table 4.4. Gamma rates ranged from a low of 54 uR/hr inside the safe to 287 uR/hr by the door of the storage shed. The entire floor area of Building A exhibited elevated gamma radiation levels.

Negligible surface alpha contamination was found in Building A. Results provided in Table 4.5 show all levels to be below the 20 dpm/100 sq. cm. limit for removable contamination. Total alpha measurements were all near 100 dpm/100 sq. cm.

TABLE 4.3

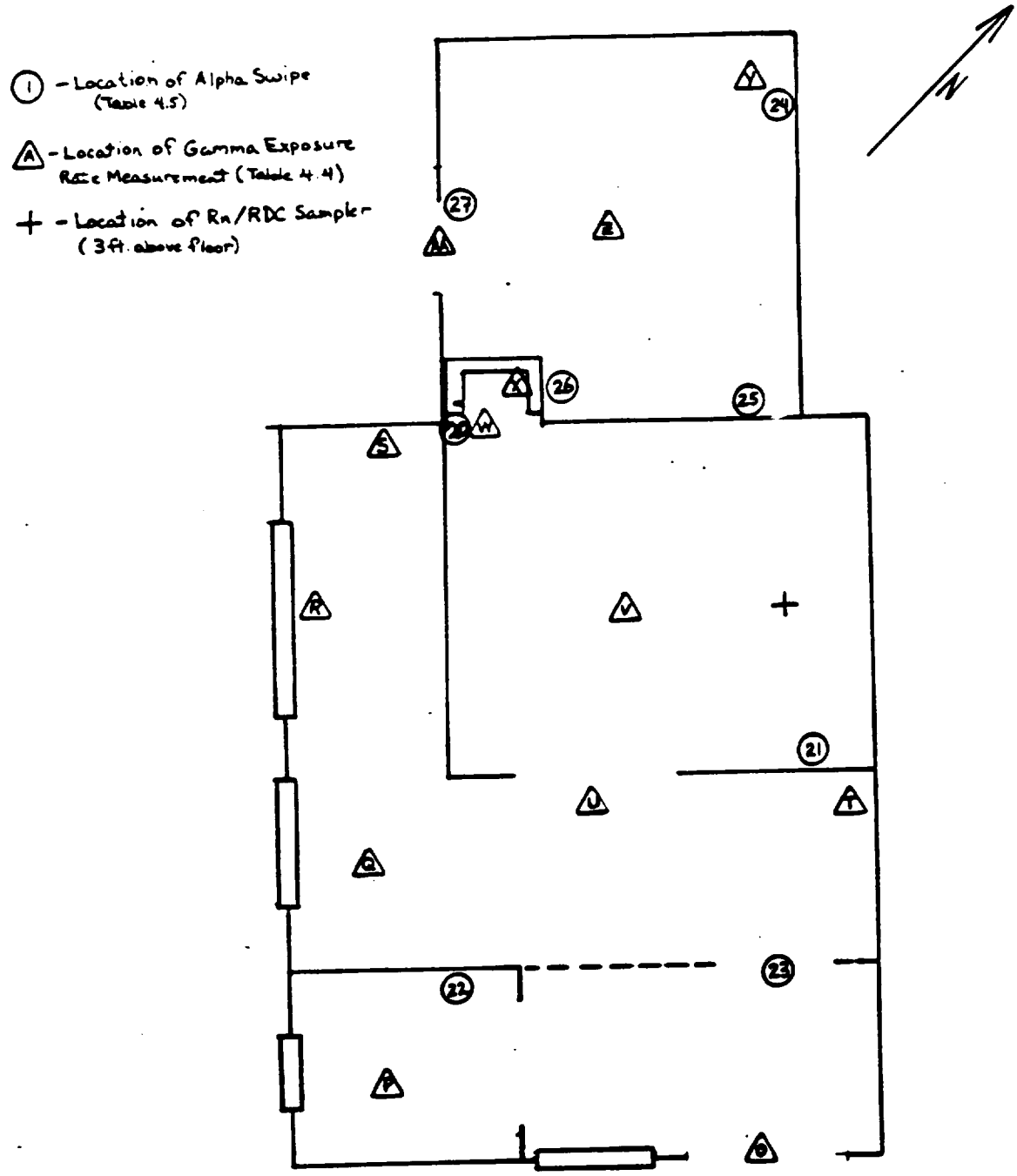
Building G (Zip) Alpha Contamination Survey Results

Location sampled	Total alpha contamination (dpm/100 sq. cm.)	Removable alpha contamination (dpm/100 sq. cm.)
11. Window Ledge (Right)	-	933.0
12. Window Ledge (Left)	-	118.0
13. Chimney	-	11.4
14. Bare Concrete (456 uR/hr)	-	7.9
15. Window Above Bare Concrete	-	19.3
16. Old Shelf	-	287.0
17. Sill Behind Old Shelf	-	293.0
18. Bottom Shelf	-	26.9
19. Office Shelf	-	15.9

- No total alpha measurement taken at this location.

(125/8)

FIGURE 4.4



1" ~ 2'

FLOOR PLAN OF BUILDING A (ORANGE-ALDEN FURNITURE COMPANY) SHOWING SAMPLING AND MEASUREMENT LOCATIONS

TABLE 4.4

Building A (Orange-Aide) Gamma Exposure Rate Survey Results

Location of Measurement	Exposure Rate (uR/hr)
O. Front Door	72
P. Toilet	58
Q. Near Desk Window	74
R. Balance Window	76
S. Near Back Door	68
T. Corner Near Air Conditioner	94
U. Office Doorway	141
V. Middle of the Office	94
W. Outer Safe	61
X. Inner Safe	54
Y. Floor of Shed	93
Z. Middle of Shed Floor	144
AA. By Door of Shed	287

(125/8)

TABLE 4.5

Building A (Orange-Alden) Alpha Contamination Survey Results

Location Sampled	Total Alpha Contamination (dpm/100 sq. cm.)	Removable Alpha Contamination (dpm/100 sq. cm.)
20. Hinges of Inner Safe Door	-	3.4
21. Under Table	-	3.4
22. Between Cracks, Bathroom Wall	-	3.4
23. Under Rug by Gate	-	1.7
24. Beam in Shed	-	5.4
25. Outer Wall of Office Building	-	2.7
26. Side of Metal Box (eye level)	-	2.7
27. Inside of Door Frame	-	4.1

- No total alpha measurements taken at this location

(125/8)

5.0 INTERPRETATION OF RESULTS

5.1 BUILDING F, T&E INDUSTRIES, INC.

Radon daughter concentrations inside Building F exceed EPA standards of 0.02 WL by a factor of fifteen. Gamma levels exceed allowable limits (background plus 20 uR/hr) by a factor of 20 in many areas. The alpha survey demonstrated that, at least in one location, long-lived removable alpha contamination exists at 170 times allowable levels (20 dpm/100 sq cm). Total alpha levels were elevated throughout Building F, most likely as a result of radon daughter plateout.

Because the survey was intended only as a general characterization of the building, it is not presently known what the extent of the contamination is. Further investigations will better define the quantities and hazard associated with the radioactive material present in Building F.

5.2 BUILDING G, ZIP PARCEL & MESSENGER SERVICE

Radon daughter concentration measurements taken in Building G are in excess of the standards by as much as a factor of 100. The percent RDC/Rn equilibrium calculated for one measurement was found to be 155%, which is an unrealistic value. A possible explanation for this is that, due to the extremely dusty conditions, particulate contamination may have gotten on the RDC filter, and increased the apparent concentration. This high equilibrium ratio could also be due to the presence of thoron progeny since the unusually high equilibrium ratio was not found in Building F, an unused, presumably now dusty, building. This hypothesis should be checked by also analyzing for thoron.

Elevated gamma levels were found throughout Building G. The owner's office had gamma levels that were also elevated (57 uR/hr), although lower than other areas in the building.

Total and removable alpha contamination exceeded allowable limits in several locations in Building G.

5.3 BUILDING A, ORANGE-ALDEN FUEL COMPANY

Rn/RDC and alpha measurements taken in Building A were in the background range for this area. As mentioned previously, the concentrations of the Rn/RDC grab sample taken in Building A was undoubtedly reduced by the ventilation of the building. The sample obtained is probably representative of the normal conditions to which employees are subject during working hours.

Gamma radiation levels were elevated throughout Building A as well as in the coal yard itself. The source of the gamma radiation can probably be traced to subsurface contamination. Shine from the adjacent properties may also contribute significantly.

6.0 CONCLUSIONS

All buildings investigated during this portion of the survey exhibited elevated radiation levels in the forms of radon/radon daughter concentrations, gamma exposure rates, or surface alpha contamination. Further investigations are needed to assess the hazards associated with these levels of radiation, and to fully characterize the radiation source.

(125/8)

APPENDIX B

U.S. RADIUM CORPORATION SITE
REPORTS OF FIELD INVESTIGATIONS

.J.

.J.
N.J. (Berg Building)

U.S. RADIUM CORPORATION
FIELD INVESTIGATION REPORT

[redacted] Avenue, South Orange, New Jersey

February 12, 1986

I. Introduction

Field investigations were performed at [redacted] Avenue, South Orange, New Jersey, on February 12, 1986, from approximately 10:00 a.m. until 12:00 p.m. the weather during this survey was sunny with freezing temperatures and several inches of snow cover remaining from the previous day.

Description

The building is used as a single-family home. It is a two-story woodframe structure with a full basement and a large attic, which is used as an office and storage area. The owner of the home, who was present during the survey, stated that the house had been built in 1920. The building was in very good condition with most surfaces recently painted, varnished or carpeted. The building was heated by a gas-fired, forced-air system, which was continuously on during the survey.

II. Field Investigation

Field Survey Team

William Smith, Onsite Coordinator
Donna Wooding, Site Safety Officer, Health Physicist
Dean Scari, Equipment and Decontamination

Radon/Radon Daughter Concentration (Rn/RDC) Measurements

Two Rn/RDC samples were taken at [redacted] Avenue. The first was collected in the eastern corner of the basement, next to the washer and dryer. This location was selected because it was near the electrical outlet furthest from the furnace. The second sample was collected in the first-floor dining room. This location was less than ideal for collecting air samples because the room had several large windows and was open to two adjacent rooms. However, as all rooms in the house had one or more windows and the heating system was operating continuously during the sampling, the second sample should reflect normal living coditions in the house.

Gamma Radiation Exposure Survey

A gamma radiation exposure scan was performed in every room the house. The highest reading was recorded for each room or area scanned. Areas showing elevated gamma levels were scanned more thoroughly, in order to more closely determine the location of contamination. All anomalous readings were recorded.

Surface Alpha Contamination

Surfaces previously determined to have elevated gamma levels were surveyed for total and removable surface alpha contamination. Additional measurements were taken to determine typical alpha activities. Eight of the ten swipe samples collected were taken in the basement and the remaining two were taken on the first floor in the vicinity of the fireplace.

III. Results

Rn/RDC Measurements

Air samples collected at [redacted] Avenue showed RDC and Rn-222 concentrations near background levels. The basement sample was found to have an RDC of 0.0094 $\pm$ 0.0020 WL and a Rn-222 concentration of 6.15 $\pm$ 1.30 pCi/l, with an equilibrium of 15%. The results were influenced by the air circulation caused by the heating system and should not be considered as accurately representing the degree of contamination in or under the building.

Gamma Radiation Exposure Survey

The gamma exposure rates measured at the 346 Richmond Avenue home ranged from 13 uR/hr, inside of a closet in the attic, to 290 uR/hr, behind the furnace in the basement (Table 1, Figure 1,2 and 3). Elevated gamma exposures were localized in three areas.

The area around the furnace appeared to have a discrete area of contamination with significantly elevated exposure rates. The highest readings were found between the furnace and the wall. Because the open area was small, it was not possible to determine the location of contamination more closely.

The fireplace on the first floor showed slightly elevated gamma levels, with a maximum reading of 31 uR/hr. The fireplace was built of red brick and red tile, which could raise gamma exposure rates to the recorded levels.

Elevated gamma readings were also observed during a scan of the area outside of the house. The highest reading was 58 uR/hr, measured next to the stone retaining wall near the driveway. The source of the gamma radiation could not be positively determined but appears to be in the wall itself. Typical gamma exposure rates were in the range of 13 to 15 uR/hr and were, slightly higher in the basement.

Surface Alpha Contamination

Levels of total surface alpha contamination were found to be elevated at all locations where swipes were taken (Table 2, Figures 1 and 2). Only one swipe sample showed longlived removable alpha contamination significantly above background. This swipe, taken in the basement at the only location in which floor paint was missing, was determined to have 9.7 dpm/100 sq cm of removable alpha contamination.

IV. Conclusions

At least one location (the area of the furnace) showed positive evidence of radiological contamination. Because of the conditions encountered during sampling, Rn/RDC results cannot be relied on as indicators of contamination. Further sampling will be needed at this property to determine the source of gamma radiation and the nature and extent of contamination.

(SPH9/10)

TABLE 1

[redacted] Avenue, South Orange, New Jersey

February 12, 1986

Gamma Exposure Rate Measurements

Location	Exposure Rate (uR/hr)
A. Basement - southwest corner near furnace	23
B. Basement - southwest corner near wall	22
C. Partitioned storage area near foot of stairs	17
D. Drainage pipes - northeast corner	17
E. Center of basement	17
F. Southeast corner of basement	16
G. Between furnace and wall - 1 m above floor	180
H. Between furnace and wall - near floor	290
I. Kitchen door near sitting room	15
J. Kitchen door near breakfast nook	14
K. Bathroom near kitchen	14
L. Breakfast nook	14
M. Dining room - near kitchen	14
N. Dining room - near windows	14
O. Dining room - near sitting room	15
P. Fireplace	31
Q. Sitting room	16
R. Sun room	18
S. Bottom of stairs	15
T. Upstairs bathroom	14
U. Upstairs sun room	14
V. Bedroom C	15
W. Bedroom A	14
X. Bedroom B	14
Y. Attic	14
Z. Closet in Attic	13

TABLE 1

[redacted] Avenue, South Orange, New Jersey
February 12, 1986

Gamma Exposure Rate Measurements

Location	Exposure Rate (uR/hr)
AA. Front steps	14
BB. Front walk	15
CC. Side door of house (north)	17
DD. Walk behind rear door	18
EE. Backyard (lower terrace)	20
FF. Steps to upper terrace	21
GG. Terrace wall by driveway	58
HH. Inside garage	17

TABLE 2

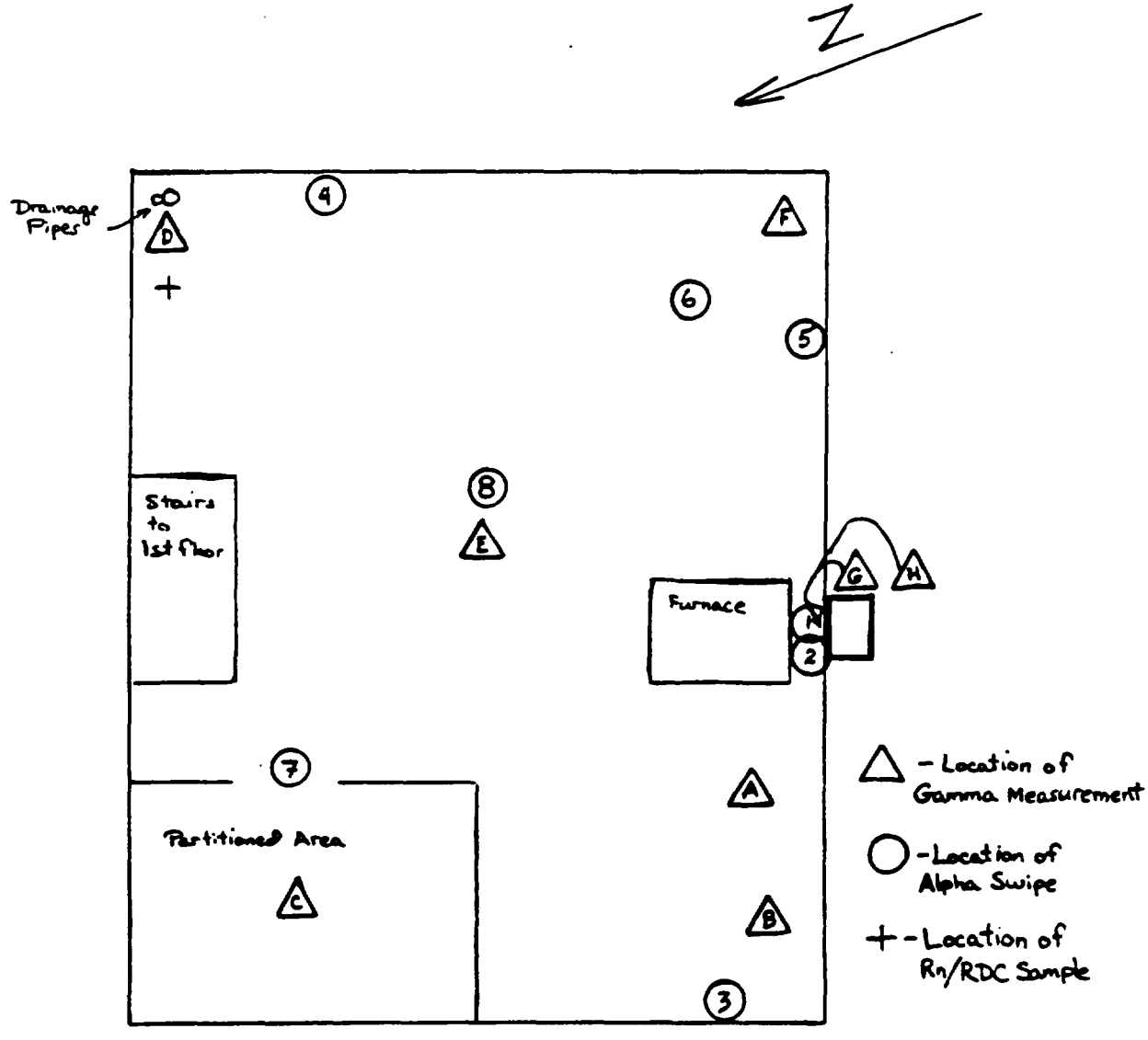
[redacted] Avenue, South Orange, New Jersey
February 12, 1986

Surface Alpha Contamination Survey

Location	Total Surface Activity (dpm/100 sq cm)	Removable Surface Activity (dpm/100 sq cm)
1. Floor behind furnace	320	4.8
2. Wall behind furnace	160	3.3
3. Window ledge-southwest corner	320	3.6
4. Ledge near cubby hole	640	3.3
5. South wall below window	640	2.7
6. Top of hot air duct-southeast corner	560	4.2
7. Floor doorway to partitioned area	800	2.4
8. Unpainted floor in middle of basement	880	9.7
9. Tile floor by fireplace	720	4.2
10. Brick lining of fireplace	160	3.6

FIGURE 1

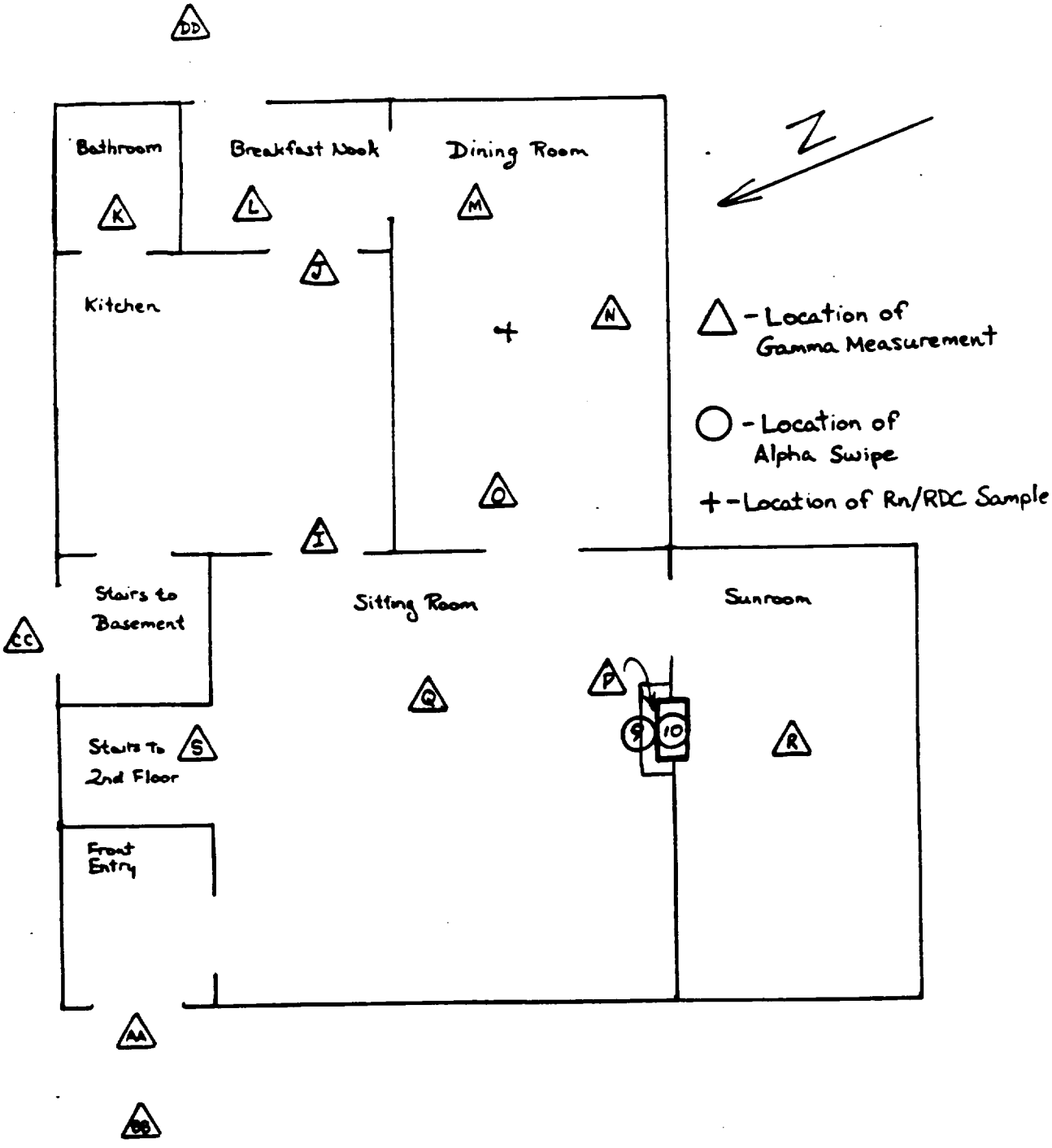
[redacted] Avenue, South Orange
(Basement)



sketched from field notes 3/3/86 LyFSmith

FIGURE 2

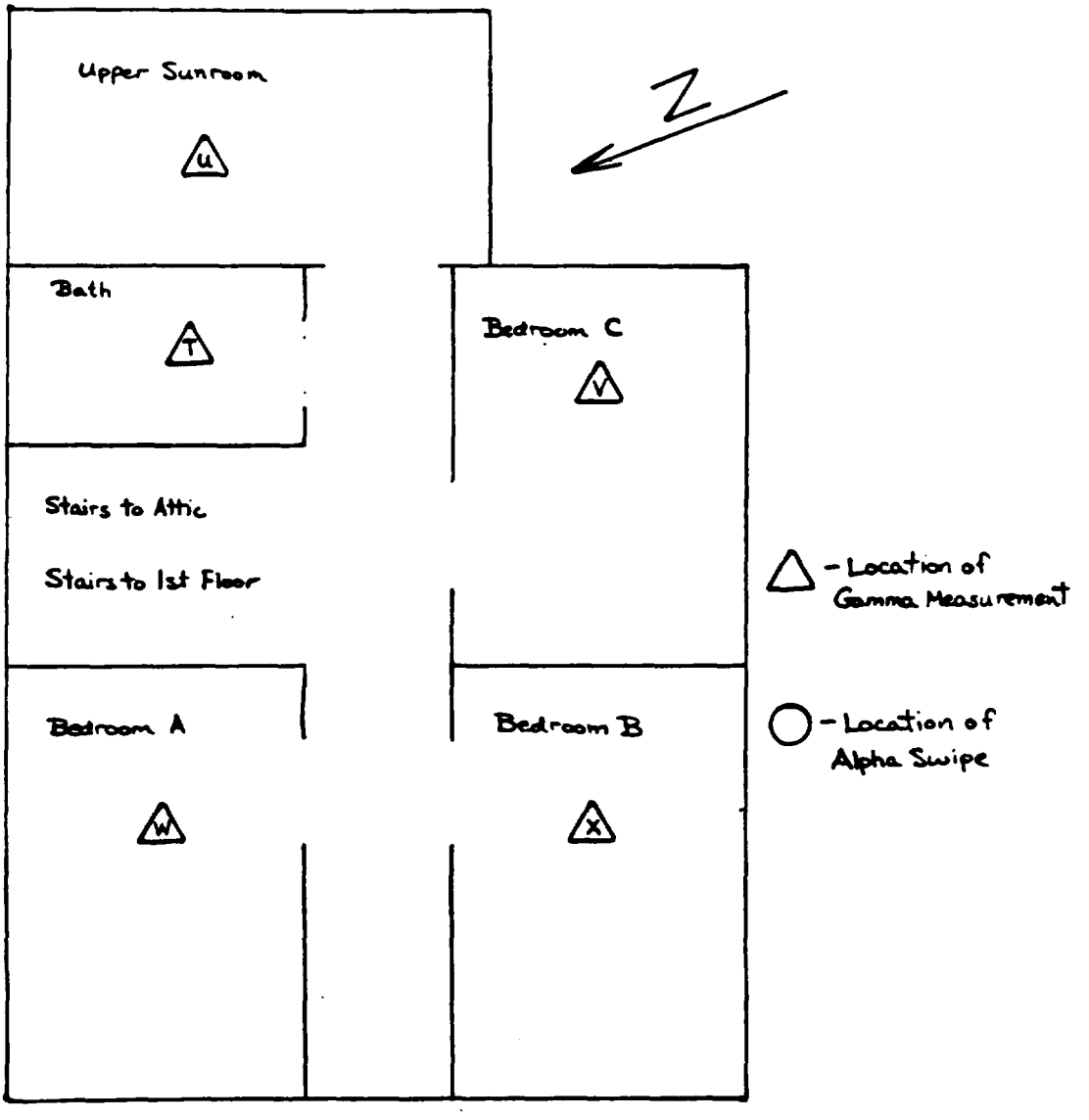
[redacted] Avenue (1st Floor)



Sketched from field notes 2/26/86 wjfsmith

FIGURE 3

[redacted] Avenue, South Orange
(2nd floor)



sketched from field notes 2/26/86 ajsmith

U.S. RADIUM CORPORATION SITE
REPORT OF FIELD INVESTIGATION

[redacted] Avenue, Orange, New Jersey

February 13, 1986

I. Introduction

Field investigations were conducted a[redacted]Avenue, Orange, New Jersey from approximately 9:00 a.m. until 11:00 a.m. the weather conditions on the day of the survey were freezing temperatures and overcast skies with a considerable amount of snow remaining on the ground from the snowfall two days earlier.

Description

The house at[redacted] Avenue is a two-story wood frame house with a basement and an attic crawl space. The basement consists of one large room with a crawl space extending under the entire kitchen at the rear of the house and an enclosed root cellar under the porch at the front of the house. On the outside of the house, the areas below the porch and kitchen are enclosed with cinder blocks. The current owner of the house told the field investigation team that the kitchen had been built by the previous owner. The first floor of the house, including the porch and kitchen, is approximately 3 feet above the ground.

In general the house was in fair condition. In several places surfaces were exposed where paint had peeled away. The basement floor is concrete, and the two upper floors have wooden floors, covered over much of their area with linoleum or carpet. Each floor is outfitted as a separate apartment. Only the ground floor was occupied, and the tenant was absent during the screening. There is an old garage with 4 bays at the rear of the property. At the time of the survey, only one bay was accessible.

II. Field Investigation

Field Survey Team

William Smith, Onsite Coordinator
Donna Wooding, Site Safety Officer, Health Physicist
Dean Scari, Equipment and Decontamination

Radon and Radon Daughter Concentration (Rn/RDC) Measurements

Two air samples were collected at the [redacted] Avenue property. At the time of the sampling, the furnace was off and had been off for at least the previous 24 hours, and all windows were closed.

Both samples were collected in the basement. The first sample was collected at the sink near the southwest corner of the basement. The second sample was collected approximately 5 feet away from the root cellar, on the floor. Sampling locations were restricted by the locations of electrical outlets.

Gamma Radiation Exposure Survey

A scan of gamma radiation exposure rates was performed over the entire area of the basement and first and second floors. The root cellar and crawl space beneath the kitchen were not scanned because of the extremely dusty condition of these areas. The attic crawl space was not accessible at the time of the survey, and thus was not scanned. Areas exhibiting elevated gamma anomalies were surveyed more thoroughly in order to locate the source of the radiation. At least one measurement was recorded for each room. Usually this was the highest reading for the room, but where no gamma anomaly was found, a typical reading was recorded instead.

Following the completion of the indoor survey, a scan of the front and backyards was performed. One bay of the garage was scanned and a single exposure rate was observed for each of the remaining bays. All anomalous readings, and some typical readings, were recorded.

Surface Alpha Contamination

The basement and the kitchen on the first floor of the building were scanned for alpha activity. Measurements of total alpha activity were made at eight locations (six in the basement and in the kitchen) and surface swipes were taken. Three of the swipes were taken in the section of the root cellar nearest the door. The survey team did not go any farther into the root cellar because of the extremely dusty, dark and confined conditions inside. In addition, the gamma exposure rate was considered to be extremely high by the health physicist, as judged from the change in pitch and frequency in the audio output of the survey meter.

III. Results

Rn/RDC Measurements

The Rn/RDC concentrations measured in the basement o[redacted] Avenue were determined to be at background levels. The first sample, taken in the rear of the basement, had a RDC of 0.0047 $\pm$ 0.0013 and a Rn-222 concentration of 0.66 $\pm$ 0.84 pCi/l, with a calculated equilibrium of 20%. The second sample, taken near the root cellar, resulted in a RDC of 0.0061 $\pm$ 0.0012 WL and a Rn-222 concentration of 1.33 $\pm$ 0.81 pCi/l. with an equilibrium of 46%. Because the house had been closed up and its heating system turned off, these values may be assumed to be representative of the RDC and Rn-222 concentrations in the areas sampled.

Gamma Radiation Exposure Survey

Indoor gamma exposure rates measured at[redacted] Avenue ranged from 13 uR/hr (in the kitchen on the second floor) to 121 uR/hr (in the basement wall, next to the root cellar) (Table 1, Figure 1, 2 and 3). A much higher exposure rate was detected in the root cellar, but was not recorded.

Elevated readings in the basement were found in the area near the root cellar and near the crawl space which extends beneath the first floor kitchen. On the first floor, elevated readings were found in the kitchen, especially by the back door. Outdoors, several locations were found to have elevated gamma exposure rates: the front porch, which is over the root cellar and the north side of the house and the back stairs, which are near the kitchen. The inside of one garage bay showed a slightly elevated reading which could not be localized, but no elevated exposures were detected outside of the garage.

Typical (non-elevated) exposure rates ranged between 13 and 17 uR/hr, both indoors and outdoors.

Surface Alpha Contamination

A scan of the basement and first floor kitchen showed a general range of total alpha activities between 240 and 480 dpm/100 sq cm (Table 2, Figures 1 and 2). Swipe samples taken in the basement were found to have slightly elevated levels of long lived removable alpha activity, ranging from 1.8 to 8.8 dpm/100 sq cm, below the criterion of 20 dpm/100 sq cm. The two swipes taken in the first floor kitchen showed background levels of alpha radiation: 2.4 dpm/100 sq cm in each case.

IV. Conclusions

Despite the low levels of RDC and Rn-222 concentrations measured, the gamma survey and surface alpha survey demonstrate that radioactive contamination is present at this property. Results of this preliminary survey suggest that contaminated materials are located in the root cellar at the front of the house and around and under the kitchen at the rear of the house. Contamination may also be present in the garage at the rear of the property. Further sampling is required at this property to define the extent and degree of radioactive contamination present.

(333/11)

TABLE 1

[redacted] Avenue, Orange, New Jersey

February 13, 1986

Gamma Exposure Rate Measurements

Location	Exposure Rate (uR/hr)
A. Foot of basement stairs	36
B. Crawlspace below kitchen (corner)	34
C. North corner of basement	17
D. East corner of basement	16
E. Highest reading in wall between basement and root cellar	121
F. Entry room 1st floor	15
G. Passage between entry room and kitchen	17
H. Kitchen - near back door	43
I. Bedroom	14
J. Front room - 2nd floor	14
K. Kitchen - 2nd floor	13
L. Bathroom - 2nd floor	14
M. Front porch - 1 meter above porch	27
N. Front porch - contact reading	36
O. Driveway - north side of house	14
P. Kitchen steps - north side	67
Q. Kitchen steps - west side	103
R. Rear of house - south side	18
S. Cellar steps	11
T. Front of house - south side	18
U. North bay of garage (high reading)	23
V. Middle of north bay	13
W. Middle of back yard	12
X. Building debris at rear of property	16
U. Building debris at front of property	23

TABLE 2

[redacted] Avenue, Orange, New Jersey
February 13, 1986

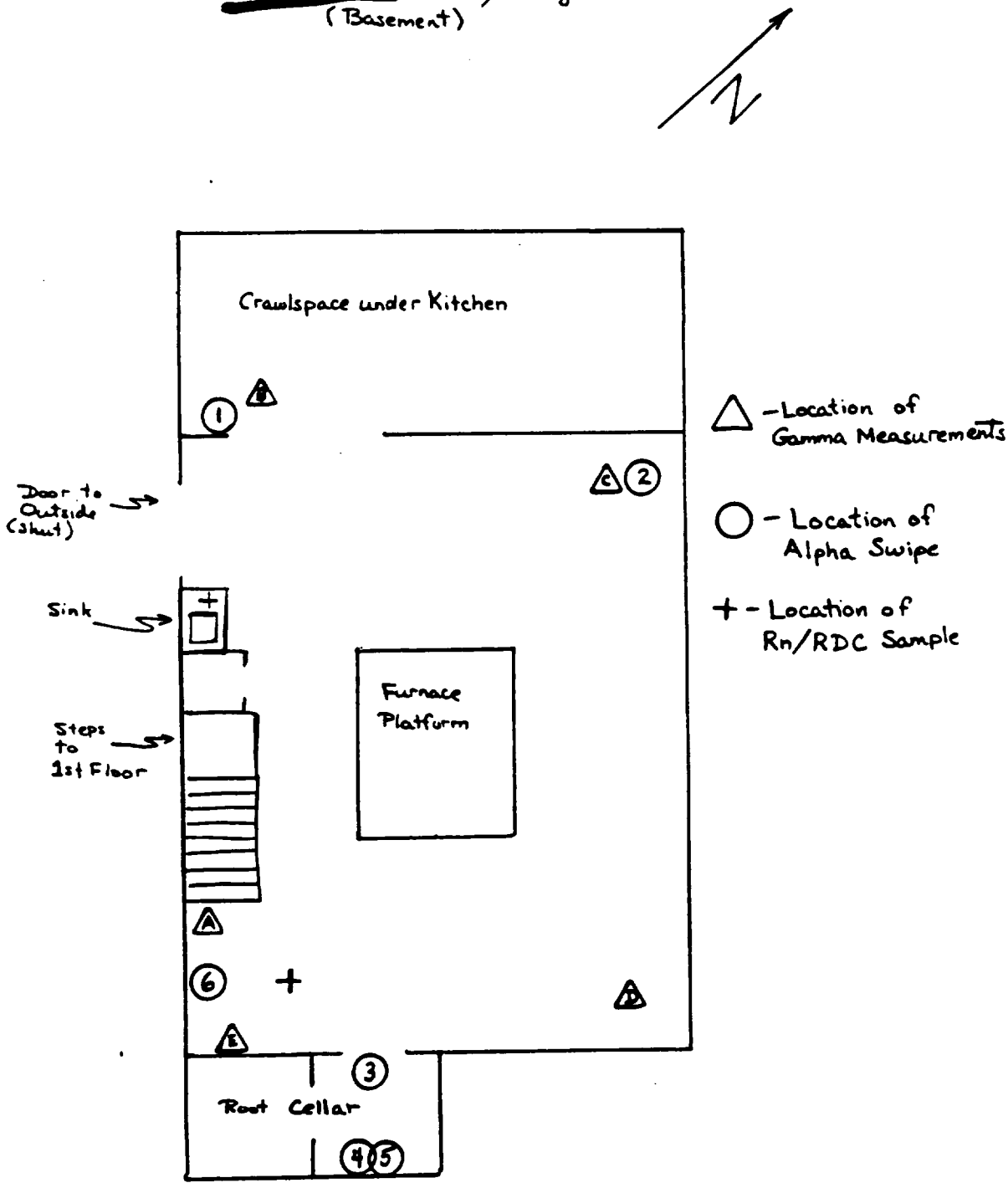
Surface Alpha Contamination Survey

Location	Total Alpha Activity (dpm/100 sq cm)	Removable Alpha Activity (dpm/100 sq cm)
1. Inside surface of crawlspace wall	240	8.8
2. Ceiling of basement-north corner	480	5.8
3. Step-inside root cellar door	*	5.5
4. Bottom shelf inside root cellar	*	6.4
5. Floor below location 4	*	4.2
6. Wood panel next to electric service	800	1.8
7. Doorknob of backdoor-inside kitchen	240	2.4
8. Room heater below kitchen window	240	2.4

* no reading because of debris on surface

FIGURE 1

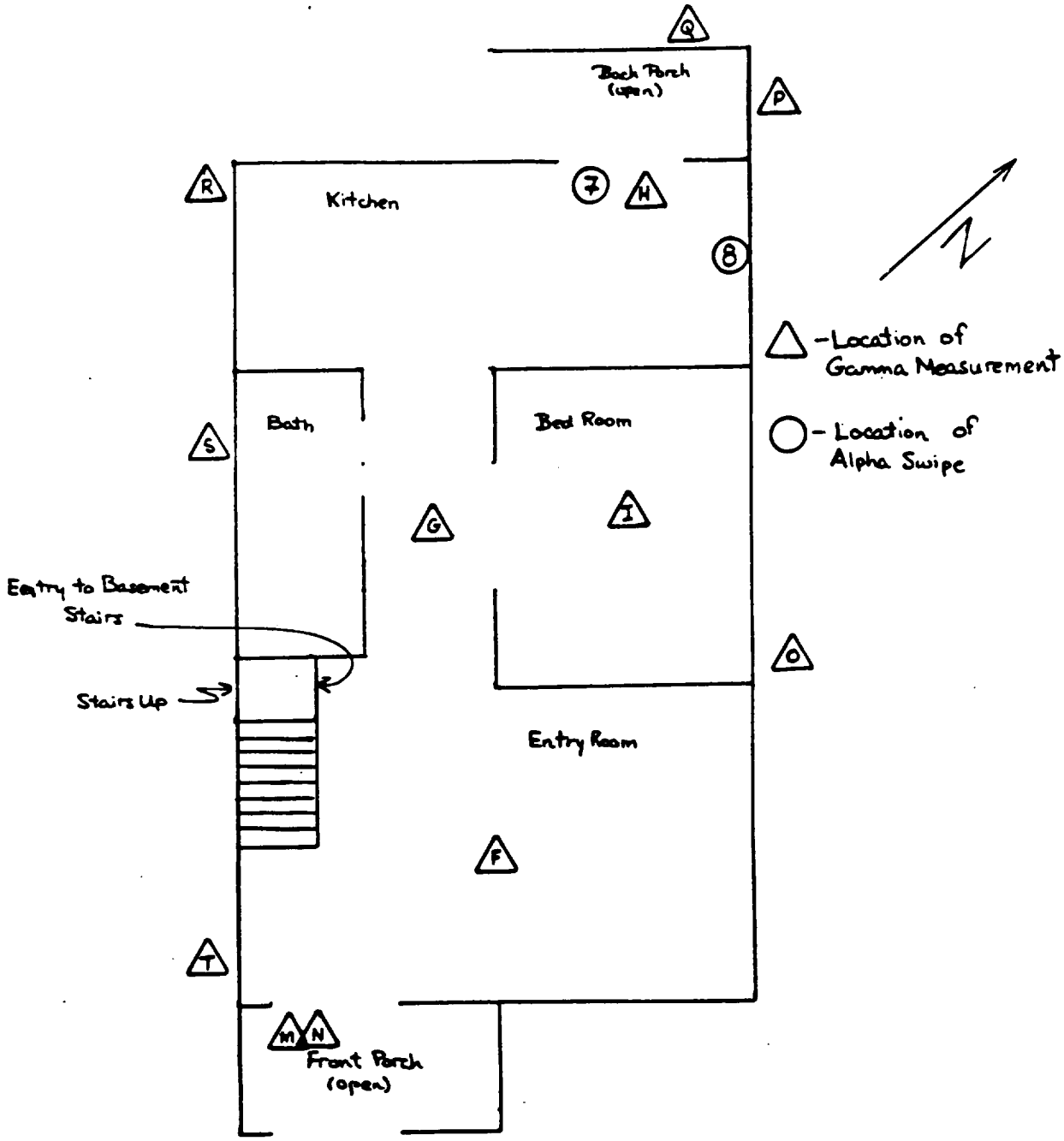
[redacted] Avenue, Orange
(Basement)



sketched from field notes 8/2/86 cjfsmith

FIGURE 2

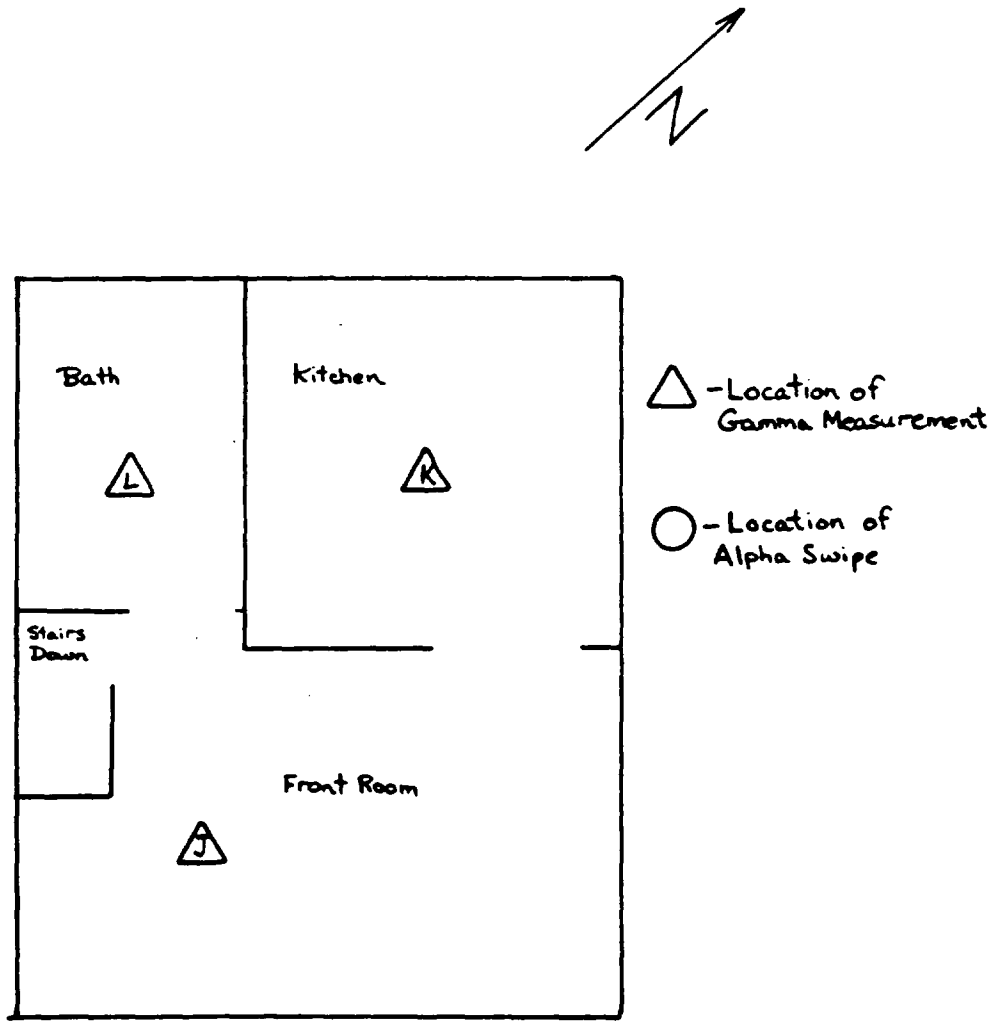
[redacted] Avenue, Orange
(1st floor)



sketched from field notes 3/2/86 [illegible]

FIGURE 3

[redacted] Avenue, Orange
(2nd floor)



sketched from field notes 3/2/86 wfsmith

U.S. RADIUM CORPORATION SITE
FIELD INVESTIGATION REPORT

[redacted] Street, East Orange, New Jersey
February 21, 1986

I. Introduction

The apartment building located at [redacted] Street, East Orange, New Jersey, was investigated for radiological contamination on February 21, 1986, from approximately 10:00 a.m. until 11:30 a.m. EST. The weather at the time of the survey was overcast and cold, with a slight drizzle.

Description

[redacted] Street is a large 3-story wood-frame building with a full basement. There are two residential apartments on each floor, connected by a hallway leading to a central stairwell. A typical apartment floor plan is shown in Figure 1. The building as a whole appears well-maintained. The building is heated through a forced-air ventilation system, with the furnace located in the basement.

The basement walls and structural supports are built of brick, which has been whitewashed or, in some locations, plastered over. One section of the basement has been partitioned and was not accessible at the time of the survey.

The owner of the building, who was present during the survey, reported that, to the best of his knowledge, the building was over 80 years old. The general appearance of the building supports that estimate of its age.

II. Field Investigation

Field Survey Team

William Smith, Onsite Coordinator
Donna Wooding, Site Safety Officer, Health Physicist
Dean Scari, Equipment and Decontamination

Radon/Radon Daughter Concentration (Rn/RDC) Measurements

A single 5-minute air sample was taken in the basement of [redacted] Street in the center of the corridor joining the two halves of the basement. This sampling location was selected because it was felt to be relatively unaffected by ventilation and because some of the higher gamma exposure rates were detected there.

Gamma Radiation Exposure Survey

Five of the six apartments were scanned for gamma activity. In addition, most of the basement, the entire central stairway from basement to roof, and the adjacent hallways were scanned. The highest reading in each room or hallway was recorded. One section of the basement was enclosed by a partition and could not be entered.

The entire backyard and the sidewalk area in front of the building were also scanned. Exposure rates measured at the corners and entrances of the house were recorded and the range of typical values was noted.

Surface Alpha Contamination

A scan of total surface alpha radiation was made only in the basement of [redacted] Street. The other floors were not scanned because gamma exposure rates were lower there than in the basement and because it was not possible to re-enter the apartments after the gamma exposure survey. The basement

walls, floor and accessible ledges were first scanned for alpha anomalies, then swipes were taken at those locations showing elevated readings. Three swipes were taken, all on wall surfaces.

III. Results of Field Investigation

Rn/RDC Measurements

Results of the analysis of the air sample indicate that only background concentrations of RDC and Rn-222 are present. A RDC of 0.0009 $\pm$0.0006 WL and a Rn-222 concentration of 0.56 $\pm$ 0.79 pCi/l were measured, with an equilibrium of 16 percent. The low ratio of RDC/Rn may result from the increased air circulation caused by the operating heater. The large uncertainties result from the low total activities detected.

Gamma Radiation Exposure Survey

The highest gamma exposure rate measured was 16 uR/hr, in an inside corner of the basement below the front entrance. In general, exposure rates in the basement were slightly higher than those on the upper floors. Slightly elevated readings were found in the hallway of the apartment building and in the bathrooms of each apartment, although no significantly elevated readings were found. Outdoors, gamma exposure rates ranged from 13 to 15 uR/hr, with the higher readings found near the street (Table 1, Figures 1 and 2).

Surface Alpha Contamination

Generally, total surface alpha activities were close to 170 dpm/100 sq cm except for three areas which showed elevated readings (Table 2, Figures 1 and 2). Swipes taken at these locations showed only slightly elevated alpha activity, indicating that any activity present was fixed onto the wall surfaces.

IV. Conclusions

Results of the survey do not indicate the presence of radioactive materials at [redacted] Street. Gamma survey results were within an acceptable range for natural background. The slightly elevated readings found in some areas may result from building materials (e.g. brick, porcelain, etc.).

RDC and Rn-222 concentrations were also in the range of background concentrations found naturally in residential structures. Effects of force ventilation caused by the operating furnace reduce the representativeness of the air sample. These results should not be used as evidence of either the presence or absence of radiological contamination.

Results of the alpha radiation scan do show that some areas of the basement have slightly elevated radioactivity. Since elevated levels of removable contamination were not found, the source of the elevated activity can not be specifically characterized without analyzing the materials in these areas.

(DEC130/5)

TABLE 1

[redacted] Street, East Orange, New Jersey
February 21, 1986

Gamma Exposure Rate Measurements

	Location	Exposure Rate (uR/hr)
A.	Basement - southwest corner of north room	16
B.	Basement - north end of connecting passage	14
C.	Basement - doorway into north room	15
D.	Basement - rear support in south room	15
E.	Basement - south room, southeast pillar	15
F.	Basement - inside stairwell	16
G.	Apt. 1A - kitchen	13
H.	Apt. 1A - bathroom	13
I.	Apt. 1A - living room	13
J.	Apt. 1A - bedroom	13
K.	Apt. 1A - room off of kitchen	13
L.	Apt. 1B - living room	13
M.	Apt. 1B - kitchen	13
N.	Apt. 1B - bathroom	15
O.	Apt. 2A - living room, rear entry	12
P.	Apt. 2A - living room, rear outer wall	12
Q.	Apt. 2A - bathroom	14
R.	Apt. 2A - room off kitchen	12
S.	Apt. 2A - bedroom	12
T.	Apt. 2B - bathroom	14
U.	Apt. 2B - room off of kitchen	13
V.	Apt. 2B - kitchen	12
W.	Apt. 2B - bedroom	12

TABLE 1
(continued)

[redacted] Street, East Orange, New Jersey
February 21, 1986

Gamma Exposure Rate Measurements

	Location	Exposure Rate (uR/hr)
X.	Apt. 2B - extra room between living room and hall	13
Y.	Apt. 2B - living room, rear outer wall	12
Z.	Hallway, 2nd floor	15
AA.	Apt. 3B - bedroom	12
BB.	Apt. 3B - extra room between living room and hall	14
CC.	Apt. 3B - living room, rear entry	14
DD.	Apt. 3B - living room, rear outer wall	12
EE.	Apt. 3B - bathroom	14
FF.	Apt. 3B - kitchen	14
GG.	Hallway - 3rd floor	16
HH.	Outside northeast corner of building	14
II.	Outside northwest corner of building	15
JJ.	Front of main entrance	14
KK.	Outside southwest corner of building	14
LL.	Outside southeast corner of building	14
MM.	Back door	13
NN.	Concrete patio	14

(DEC130/5)

TABLE 2

[redacted] Street, East Orange, New Jersey
February 21, 1986

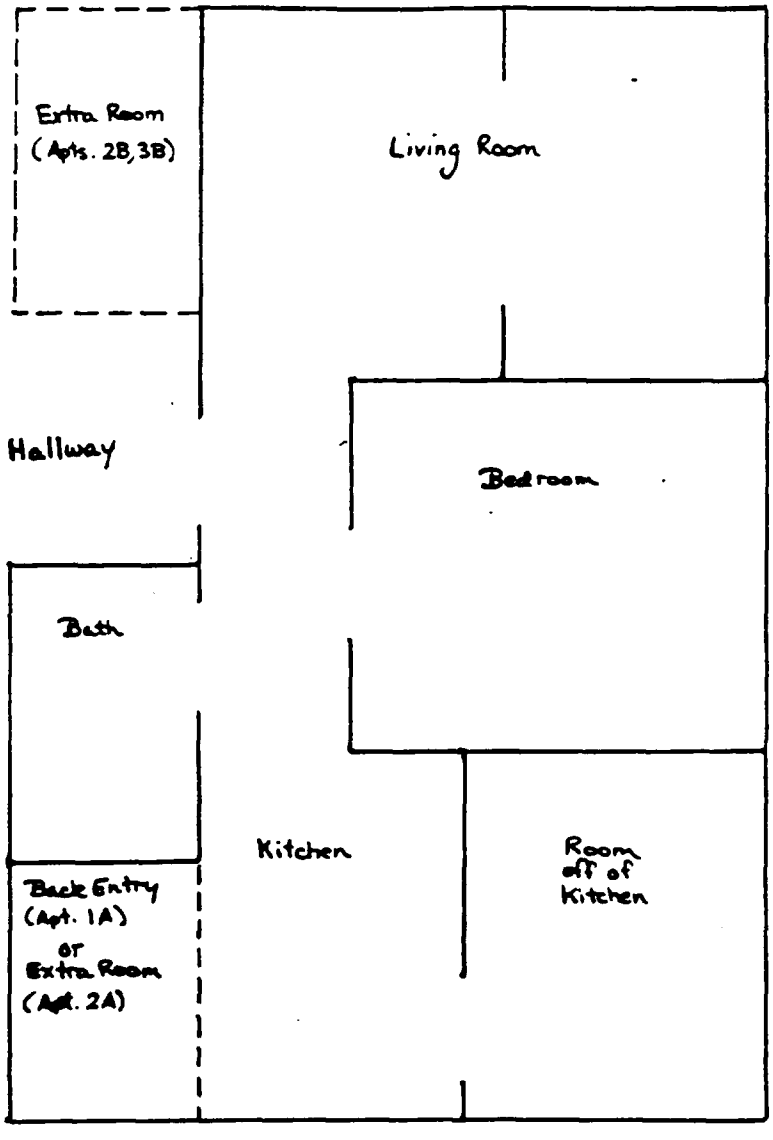
Surface Alpha Contamination Survey

Location	Total Surface Activity (dpm/100 sq cm)	Removable Surface Activity (dpm/100 sq cm)
1. South wall of stairwell	250	4.2
2. South wall - bare patch of wall	417	4.9
3. Front support - south room	500	4.2

(DEC130/5)

FIGURE 1

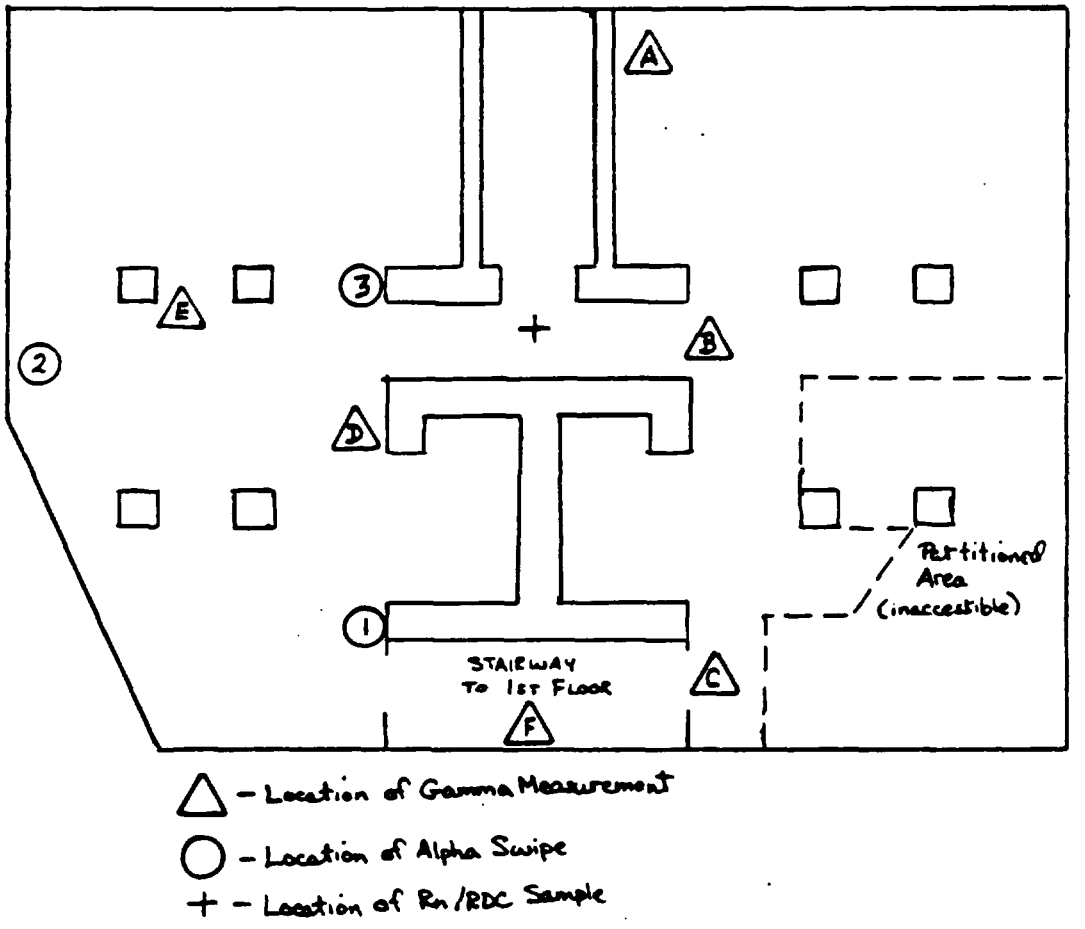
[redacted] Street, Orange
(Representative Apartment Floor Plan)



sketched from field notes 3/3/86 [redacted]

FIGURE 2

[redacted] Street, Orange
(Basement)



sketched from field notes 3/3/86 WJSmith

U.S. RADIUM CORPORATION SITE
FIELD INVESTIGATION REPORT

[redacted] Street, Orange, New Jersey
(Berg Building)

February 11, 1986

I. Introduction

Field measurements were taken in the Berg Building on February 11, 1986, from approximately 10:00 a.m. until 2:00 p.m. Weather conditions (freezing temperatures and heavy snow) prevented any outdoor survey at that time.

Description of Building

The Berg Building is a single structure occupying almost the entire west side of [redacted] Street between [redacted] and [redacted] Street in Orange, New Jersey. The northerly section of the building is constructed of red brick and has 3 stories above the basement level. The southerly end of the building is also of brick, but has a yellow colored veneer. This end of the building has 6 floors above the basement level. Structural walls partition the lower 3 floors and basement of the building into three sections of roughly equal size. A stone inset in the face of the building has the dates 1864 and 1903.

The Berg Building is currently undergoing a major renovation of its interior, which involves gutting and refurbishing the entire building. Most of the building has been gutted, uncovering the original wood flooring and wood structural supports. Renovation of the second floor is substantially complete. New windows have been throughout the level, the floor has been retiled and the entire floor area has been partitioned into small offices.

The first floor of the Berg Bulding is used as office and warehouse space by the building's owner and the basement houses storage, sorting and baling operations for a rag recycling company. The sixth floor has two tenant businesses. One, a zinc aluminum casting shop, was in operation the day of the field investigation. The remainder of the building is used for storage of various materials.

Near the main entrance to the Berg Building is an undated drawing of the Berg Building and two neighboring structures [redacted] Street a[redacted] Street). All three buildings appear in the drawing much as they do today, except that a sizeable portion of the smokestack at [redacted] Street is missing.

II. Field Investigation

Field Survey Team

William Smith (CDM)	On Site Coordinator
Donna Wooding (RFW)	Site Safety Officer, Health Physicist
Dean Scari (CDM)	Equipment and Decontamination

Radon and Radon Daughter Concentration (Rn/RDC) Measurements

Two Rn/RDC samples were collected on the first floor of the Berg Building. No samples were collected in the basement as there were no accessible electrical outlets to power the pump. One sample was taken at one side of the film storage area near the middle of the building, and the second was collected at the far northern end of the building. The heating system was on during sample collection and the large bay doors to that area had just been opened, allowing a substantial increase in air circulation.

Gamma Radiation Exposure Survey

Gamma radiation exposure rates were measured throughout all floors of the Berg Building. Rooms and hallways were scanned in an attempt to locate and quantify the highest exposure rate in each room or area. Additional measurements were recorded in order to establish the range of background exposure rates.

Surface Alpha Contamination

Alpha radiation measurments were made in locations previously found to have elevated gamma radiation exposures and some additional areas throughout the second, third and sixtn floors were also scanned. Total alpha measurements were recorded at four locations in the metal shop on the sixth floor and swipes were taken at these locations for the measurement of removable alpha contamination.

III. Results

Rn/RDC Measurements

Both air samples showed Rn/RDC levels that were essentially at background. The sample taken in the film storage room resulted in a RDC of 0.0019 $\pm$ 0.001 WL and a Rn-222 concentration of 0.19 $\pm$ 0.45 pCi/l, with an equilibrium near 100%. The sample taken the northern end of the storage room showed a RDC of 0.0022 $\pm$ 0.001 WL and a Rn-222 concentration of 0.38 $\pm$ 0.31 pCi/l. Because the concentrations were so low, the associated measurement uncertainties were very large, and the calculated equilibria are probably higher than the actual. However, the Rn/RDC values obtained cannot be used to substantiate or refute the presence of radium contamination in this building, because the results may have been grossly affected by the heating system and the open bay doors.

Gamma Radiation Exposure Rates

Exposure rates in the Berg Building ranged from a low of 10 uR/hr on the second floor to 27 uR/hr at one location on the sixth floor. The great majority of the exposure readings were between 15 and 17 uR/hr (Table 1). It was found that most of the structural walls produced exposures slightly greater than the rest of the areas scanned. This is probably due to the bricks used in their construction. Similarly, the brick passage connecting the two sections of the red brick portion of the building exhibited significantly elevated exposures in all three floors and in the basement. These exposures ranged from approximately 17 uR/hr to 24 uR/hr. The restrooms on all floors showed slightly elevated gamma radiation levels, presumably the result of the building materials used.

The highest levels of gamma radation were found on the sixth floor and appeared to be centered on a discrete area of contamination in the floor. The maximum exposure rate obtained was 27.3 uR/hr.

Surface Area Contamination

The total surface alpha activity scan in the Berg Building generally ranged from 90 to 150 dpm/100 sq cm (Table 2). Only two of the sample locations indicated greater activities. All four removable surface activity swipe samples showed elevated long-lived alpha activity, but none exceeded 20 dpm/100 sq cm. All swipes were taken within the area of elevated gamma activity found on the sixth floor, and are thus expected to be representative of the materials present. It should be noted, however, that over the past 60 years virtually all floor and wall surfaces have been painted, possibly preventing the detection of alpha emissions.

IV. Conclusions

Results of the radiological characterization of the Berg Building have shown some elevated gamma exposure rates as well as elevated surface alpha contamination. Areas of elevated radioactivity will require further investigation in order to determine the source, activity and extent of contamination within the Berg Building. In addition, the other structures associated with the Berg Building as shown in the undated drawing, should also be characterized as they are also possible locations of U.S. Radium Corporation activities.

(SPH2/27)

TABLE 1

[redacted] Street, Orange, New Jersey
(Berg Building)
February 11, 1986

Gamma Exposure Rate Measurements

Location	Exposure Rate (uR/hr)
A. Sidewalk - in front of main entrance	14
B. Lobby	18
C. Stairwell (1st floor)	18
D. Room A200 (center)	10
E. Room A201 (center)	16
F. Room A202 (center)	16
G. Stairwell (2nd floor)	16
H. Hallway - near room A202	16
I. Room A203	16
J. Room A204	17
K. Room A205	16
L. Room A206	16
M. Room A207	16
N. Room A208	16
O. Hallway - northwest corner of tall section	16
P. Room 210B	16
Q. Room 211B	14
R. Room 212B	16
S. Room 213B	15
T. Room 214B	15
U. Room 215B	14
V. Room 216B	14
W. Room 217B	16
X. Room 218B	16
Y. Room 219B	16
Z. Room 220B	17

TABLE 1

[redacted] Street, Orange, New Jersey
(Berg Building)
February 11, 1986

Gamma Exposure Rate Measurements

Location	Exposure Rate (uR/hr)
AA. Women's room - next to 220B	19
BB. Narrow brick passage on 2nd floor	23
CC. Men's room -next to 221C	20
DD. Room 221C	15
EE. Room 222C	15
FF. Room 223C	14
GG. Room 224C	15
HH. Room 225C	15
II. Room 226C	15
JJ. Room 227C - northeast corner of building	18
KK. Room 228C	16
LL. Hallway - 2nd floor, north end	17
MM. 3rd floor landing of stairwell, above building entrance	18
NN. Basement landing of stairwell, below building entrance	15
OO. Women's room - 3rd floor between sections B and C	19
PP. Washroom - 3rd floor between sections B and C	20
QQ. Narrow brick passage on 3rd floor	24
RR. Room behind brick passage on 3rd floor	22
SS. Brick wall on west side of 3rd floor	18
TT. Storeroom - 1st floor, section A	14
UU. Rear office - 1st floor, section A	16
VV. Office of J. Sweetwood - 1st floor, section A	16

TABLE 1

[redacted] Street, Orange, New Jersey
(Berg Building)
February 11, 1986

Gamma Exposure Rate Measurements

Location	Exposure Rate (uR/hr)
WW. Office of B. Sweetwood - 1st floor, section A	15
XX. Main office - 1st floor, section A	15
YY. Kitchen - 1st floor, section A	15
ZZ. Conference room - 1st floor, south end	18
AAA. Narrow brick passage - 1st floor, south end	18
BBB. Narrow brick passage - 1st floor, north end	20
CCC. North end of 1st floor	18
DDD. Washroom - 1st floor	21
EEE. 3rd floor - section A, south end	16
FFF. 3rd floor - section A, north end	16
GGG. 6th floor - northwest section	27
HHH. Basement - south end	19
III. 5th floor - washroom	17

(327/6)

TABLE 2

[redacted] Street, Orange, New Jersey
(Berg Building)
February 11, 1986

Alpha Contamination Survey Results

Location	Total Surface Activity (dpm/100 sq cm)	Removable Surface Activity (dpm/100 sq cm)
1. 6th floor - location 1	364	13.3
2. 6th floor - location 2	727	8.8
3. 6th floor - location 3	109	18.5
4. 6th floor - location 4	91	9.7

U.S. RADIUM CORPORATE SITE
FIELD INVESTIGATION REPORT

[redacted] Street, Orange, New Jersey

February 17, 1986

I. Introduction

A gamma radiation exposure scan was made of the inside of [redacted] Street, Orange, New Jersey, on February 17, 1986, from approximately 9:30 a.m. to 10:30 a.m. the weather was freezing temperatures with some wind and cold drizzle. Much frozen snow cover remained from the previous week. This building was scanned because it was part of the original F. Berg & Co. complex and may have been included in the [redacted]treet address.

Description of Building

There are three sections to the building at 564 Forest Street. The largest section is two stories high and is made of brick. Access to this section could not be obtained, so no further investigation could be made. Attached to this section is a four-story brick structure with no basement. There is a central staircase connecting all four floors. The third section is a low one-story structure attached to the four-story structure. This part of the building appears to have been the boilerhouse of the F. Berg & Co. complex, but is not now in use. This area was not entered as no safe access was seen.

The main building is occupied by various tenants involved in light manufacture. Only four of the tenants were available on the day of the survey and only two allowed the field team to scan their premises.

II. Field Investigation

Approximately half of the four-story section of the building was scanned for gamma activity. The areas scanned were the ground floor entrance area, a first-floor room used for storage of cardboard sheet, and a furniture refinishing shop on the third floor. The other businesses in the building were closed.

All accessible areas were scanned and the highest readings in each section were recorded.

III. Results

No anomalously elevated exposures were encountered. Measured exposure rates ranged from 13 to 16 uR/hr, with the higher readings encountered near the structural walls (Table 1). Only about one-fourth of the first floor storage area could be scanned, due to the number of bales of cardboard stored there. This cardboard could have prevented detection of gamma radiation anomalies.

IV. Conclusions

The parts of [redacted] Street that were surveyed showed no sign of radiological contamination. However, no conclusion can be reached by this report since a large part of the building remains to be scanned. Further investigation is needed.

(SPH9/15)

TABLE 1

[redacted] Avenue, Orange, New Jersey
February 17, 1986

Gamma Exposure Rate Measurements

Location	Exposure Rates (uR/hr)
A. Center storeroom - 1st floor	13
B. Brick wall	16
C. Stairwell - 1st floor	14
D. Alcove at end of hall - 1st floor	15
E. Door to locked room - 1st floor	13
F. 3rd floor - east end	14
G. Wood platform - 3rd floor, north wall	14
H. 3rd floor - west end	15

U.S. RADIUM CORPORATE SITE
FIELD INVESTIGATION REPORT

[redacted] Street, Orange, New Jersey

February 17, 1986

I. Introduction

A gamma radiation exposure scan was made in and around [redacted] Street, Orange, New Jersey, on February 17, 1986, at approximately 11:15 a.m. The weather was chilly with some wind and cold drizzle. Much frozen snow cover remained from the previous week. This building was scanned because it was part of the original F. Berg & Co. complex and may have been included in the [redacted] Street address.

Description of Building

[redacted] Street is a one story brick building with a loft space at the south end. The northern section of the building is open and the interior of this section is partially demolished. One portion of the concrete flooring has collapsed and it appears that there is also a basement to the building. The southern section of the building consists of two enclosed rooms, used for storage of various electrical equipment. There are several partitioned sections within these rooms and a loft area above. This section of the building does not appear to be in regular use, and there is no obvious access to the loft from the ground floor.

II. Field Investigation

Approximately three-quarters of the ground floor level of the building was scanned for gamma exposure rates. The only areas not scanned were the section of the floor which was caved in and the loft, which was inaccessible. The ground immediately around the building was also scanned.

Changes in gamma exposures rates were monitored using the audio output from the gamma survey meter.

III. Results of Field Investigation

Gamma exposure rates did not vary significantly from 14 uR/hr across the areas surveyed.

IV. Conclusion

There is no evidence of gross radioactive contamination in the area surveyed. As this building is not in regular use and does not appear suitable for any use other than storage, no further investigation is recommended.

(SPH9/14)